

# Appendix A

*Geographic Information  
System (GIS)*

This appendix describes the 53 digital Geographic Information System (GIS) geologic units that comprise the Bear River Basin (BRB) of Wyoming, Utah, and Idaho. The stratigraphic descriptions in this appendix are for the units shown on Plate I. The 53 digital GIS geologic units are distributed as follows:

<i>Wyoming</i>	<i>28 geologic units</i>	<i>page A1-11</i>
<i>Utah</i>	<i>21 geologic units</i>	<i>page A11-14</i>
<i>Idaho</i>	<i>4 geologic units</i>	<i>page A1-11</i>

These geologic units are compiled from the 1:500,000-scale digital state maps that cover the BRB. The maps give a code and rock-type description to each unit within the mapped state; each state has its own set of codes, and neither codes nor unit boundaries necessarily match across state lines.

In this appendix, for each state, each geologic unit symbol (**bold face**) and GIS definition (underlined) is followed by a description of the corresponding stratigraphic unit(s) as defined in that state. **Plate 1** summarizes these determinations. Rock-stratigraphic units that appear in the right-hand column of **Plate 1** are in **boldface**.

## BEAR RIVER BASIN GEOLOGIC UNITS – WYOMING

There are 28 digital GIS geologic units in the Wyoming portion of the Bear River Basin (Love and Christiansen, 1985). The stratigraphic descriptions below are taken directly from Love and Christiansen (1985) with minor modifications. Unit labels for Utah and Idaho can be found at the end of the unit description for correlative units.

### *References*

- Love, J.D., and Christiansen, A.C., *compilers*, 1985, Geologic map of Wyoming: U.S. Geological Survey, scale 1:500,000, 3 sheets.
- Love, J.D., Christiansen, A.C., and Ver Ploeg, A.J., *compilers*, 1993, Stratigraphic chart showing the Phanerozoic nomenclature for the state of Wyoming: Geological Survey of Wyoming Map Series 41 (MS-41).

### Symbol      Unit Description

## CENOZOIC GEOLOGIC UNITS – WYOMING

### *Quaternary geologic units – Wyoming, Utah, and Idaho*

**Qa**      Alluvium and colluvium (Holocene-Pleistocene) – Clay, silt, sand, and gravel in flood plains, fans, terraces, and slopes. Idaho - **Qa**

**Qg**      Glacial deposits (Holocene-Pleistocene) – Till and outwash of sand, gravel, and boulders.

**Qls**      Landslide deposits (Holocene-Pleistocene) – Local intermixed landslide and glacial deposits, talus, and rock-glacier deposits.

**Qt**      Gravel, pediment, and fan deposits (Holocene-Pleistocene) – Mostly locally derived clasts; locally includes some Tertiary gravels.

Symbol                      Unit Description

**Qu**     Undivided surficial deposits (Holocene-Pleistocene) – Mostly alluvium, colluvium, and glacial and landslide deposits.

Quaternary and Tertiary geologic units – Wyoming, Utah, and Idaho

**QTg**   Terrace gravel (Pleistocene and (or) Pliocene) – Partly consolidated gravel above and flanking some major streams. Utah - **Qao**

*Tertiary geologic units – Wyoming, Utah, and Idaho*

**Tsl**     Salt Lake Formation (Pliocene and Miocene) – White, gray, and green limy tuff, siltstone, sandstone, and conglomerate. Utah – **T4**, Idaho - **Ted**

**Tbi**     Bishop Conglomerate (Oligocene) – Clasts of red quartzite, gray chert, and limestone in a gray to white tuffaceous sandstone matrix.

**Tf**       Fowkes Formation (Pliocene(?) and Eocene) – Light-colored tuffaceous sandstone and siltstone, locally conglomeratic. Locally designated by some as Norwood Tuff. Utah – **T2**

**Tgrw**   Green River and Wasatch Formations (Eocene)

Green River Formation – Buff laminated marlstone and limestone, brown oil shale, and siltstone, includes Angelo and Fossil Butte Members.

Wasatch Formation – Variegated mudstone and sandstone. Includes Tunp and Bullpen Members, other tongues and unnamed members, and main body.

**Twd**     Wasatch Formation (Diamictite and sandstone) (Eocene) – Diamictite grades laterally into other members of the formation

**Tw**       Wasatch Formation (main body) (Eocene) – Thrust Belt – Variegated red to gray, brown, and gray mudstone and sandstone; conglomeratic lenses.

          Southwest Wyoming – Drab to variegated claystone and siltstone, carbonaceous shale and coal, buff sandstone, arkose, and conglomerate. Utah – **T1**

**Tcs**     Conglomerate of Sublette Range (Eocene and Paleocene) – Locally derived indurated angular conglomerate.

Tertiary and Cretaceous geologic units – Wyoming, Utah, and Idaho

**TKe**     Evanston Formation (Paleocene and Upper Cretaceous) – Gray siltstone, sparse red sandstone, and lignite beds.

*Cretaceous geologic units – Wyoming, Utah, and Idaho*

**Kav**     Adaville Formation (Upper Cretaceous) – Gray sandstone, siltstone, and carbonaceous claystone; conglomeratic in upper part; coal-bearing in lower part.

Symbol                      Unit Description

**Kh**      Hillard Shale (Upper Cretaceous) – Dark gray to tan claystone, siltstone, and sandy shale.

**Kf**      Frontier Formation (Upper Cretaceous) – White to brown sandstone and dark-gray shale; oyster coquina in upper part; coal and lignite in lower part. Utah – **K2**

**Kss**      Sage Junction, Quealy, Cokeville, Thomas Fork, and Smiths Formations (Lower Cretaceous)

Sage Junction Formation – Gray and tan siltstone and sandstone.

Quealy Formation – Variegated mudstone and tan sandstone.

Cokeville Formation – Tan sandstone, claystone, limestone, bentonite, and coal.

Thomas Fork Formation – Variegated mudstone and gray sandstone.

Smiths Formation – Ferruginous black shale and tan to brown sandstone.

**Ka**      Aspen Shale (Lower Cretaceous) – Light to dark-gray siliceous tuffaceous shale and siltstone, thin bentonite beds, and quartzitic sandstone. Utah – **K1**

**Kg**      Gannett Group (Lower Cretaceous) – Red sandy mudstone, sandstone, and chert-pebble conglomerate; thin limestone and dark-gray shale in upper part, more conglomeratic in lower part. Includes Smoot Formation (red mudstone and siltstone), Draney Limestone, Bechler Conglomerate, Peterson Limestone, and Ephraim Conglomerate. Upper Jurassic fossils have been reported from the Ephraim. Idaho - **KI**

*Jurassic geologic units – Wyoming, Utah, and Idaho*

**Jst**      Stump Formation, Preuss Sandstone or Redbeds, and Twin Creek Limestone (Upper and Middle Jurassic) Utah - **J1**, Idaho - **Ju**

Stump Formation – Glauconitic siltstone, sandstone, and limestone.

Preuss Sandstone or Redbeds – Purple, maroon, and reddish-gray sandy siltstone and claystone; contains salt and gypsum in thick beds in some subsurface sections.

Twin Creek Limestone – Greenish-gray shaly limestone and limy siltstone. Includes Gypsum Spring Member.

*Jurassic and Triassic geologic units – Wyoming, Utah*

**JTn**      Nugget Sandstone (Jurassic and Triassic) – Buff to pink crossbedded well-sized and well-sorted quartz sandstone and quartzite; locally has oil and copper-silver-zinc mineralization.

*Triassic geologic units – Wyoming, Utah, and Idaho*

**Trd**      Ankareh Formation, Thaynes Limestone, Woodside Shale, and Dinwoody Formation (Upper and Lower Triassic) Utah – **Tr1**

Ankareh Formation – Red and maroon shale and purple limestone.

Thaynes Limestone – Gray limestone and limy siltstone.

Woodside Shale – Red siltstone and shale.

Dinwoody Formation – Gray to olive-drab dolomitic siltstone.

Symbol	Unit Description
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*Permian geologic units – Wyoming, Utah*

Pp	<u>Phosphoria Formation</u> (Permian) – Upper part is dark- to light-gray chert and shale with black shale and phosphorite at top; lower part is black shale, phosphorite, and cherty dolomite. Utah – P2
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*Permian, Pennsylvanian, and Mississippian geologic units – Wyoming, Utah*

PPMa	<u>Phosphoria, Wells, and Amsden Formations</u> (Permian-Upper Pennsylvanian) Utah - PP <u>Phosphoria Formation</u> (Permian) – Upper part is dark- to light-gray chert and shale with black shale and phosphorite at top; lower part is black shale, phosphorite, and cherty dolomite. <u>Wells Formation</u> – Gray limestone interbedded with yellow limy sandstone. <u>Amsden Formation</u> – Red and gray cherty limestone and shale, sandstone, and conglomerate.
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PPM	<u>Wells and Amsden Formations</u> (lower Permian-Upper Mississippian) <u>Wells Formation</u> – Gray limestone interbedded with yellow limy sandstone. <u>Amsden Formation</u> – Red and gray cherty limestone and shale, sandstone, and conglomerate.
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*Pennsylvanian geologic units – Wyoming, Utah*

Pzr	<u>Paleozoic rocks (undifferentiated)</u> – May include Madison Limestone, Darby Formation, and Bighorn Dolomite. Utah - P
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*Mississippian and Devonian geologic units – Wyoming, Utah*

MD	<u>Madison Group and Darby Formation</u> (Upper Mississippian-Upper Devonian) Utah –
M2	<u>Madison Limestone or Group</u> – Group includes Mission Canyon Limestone (blue-gray, massive limestone and dolomite), underlain by Lodgepole Limestone (gray cherty limestone and dolomite). <u>Darby Formation</u> – Yellow and greenish-gray shale and dolomitic siltstone underlain by fetid brown dolomite.

Uncorrelated Utah geologic units – **M1**, Gardison/Lodgepole Limestone, **D**, Beirdneau Sandstone, Hyrum Dolomite, and Water Canyon Formation

*Silurian geologic units – Wyoming, Utah*

Sl	<u>Laketown Dolomite</u> (Upper and Middle Silurian) – Light-gray thick-bedded finely crystalline dolomite. Utah - S
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Symbol                      Unit Description

Ordovician and Cambrian geologic units – Wyoming, Utah

**O€**    Bighorn Dolomite, Gallatin Limestone, and Gros Ventre Formation (Upper Ordovician-Middle Cambrian) Utah - **O**

Bighorn Dolomite – Gray massive cliff-forming siliceous dolomite and locally dolomitic limestone.

Gallatin Limestone – Gray and tan limestone.

Gros Ventre Formation – Greenish-gray micaceous shale.

Uncorrelated Utah geologic units: **C3** - St Charles Formation, Nounan Dolomite, and Blooming-ton Formation, **C2** – Maxfield Limestone and Ophir Formation, **C1** – Tintic Quartzite

*Precambrian geologic units – Utah*

Uncorrelated Utah geologic units: **PCs** – Mutual Formation, Mineral Fork Tillite, and Big Cottonwood Formation.

# Appendix B

*WWDC Groundwater  
Studies*

Citation(s)	Location	Aquifer/ Formation	Project Description	Results/Recommendations	Current Status
<u>Wyoming River Basins</u>					
Wyoming. Water Planning Program, 1973, Wyoming's groundwater supplies: Cheyenne, Wyoming State Engineer's Office, Wyoming Water Planning Program Report, variously paged.	Wyoming	All	Summary of available groundwater and groundwater sources.	Predictions of aquifer water quantity throughout the state of Wyoming.	N/A
WWC Engineering, Inc., 2007a, in association with Hinckley Consulting, Collins Planning Associates, Greenwood Mapping, Inc., and States West Water Resources Corporation, Wyoming framework water plan: prepared for the Wyoming Water Development Commission, Cheyenne, Wy., v. 1 and 2, variously paged.					
<u>Bear River Basin</u>					
Forsgren and Associates 2001, in association with Anderson Consulting Engineers, Inc., Leonard Rice Engineers, Inc., and BBC Research and Consulting, Bear River Basin water plan, final report and technical memoranda: prepared for the Wyoming Water Development Commission, variously paged.	Bear River Basin	All	Develop basin plans with participation from local interest groups that provide defensible hydrologic data to quantify surface and ground water uses.	Current surface and ground water uses, water quality, future demand projects and future water use opportunities quantified and discussed.  Continue with planning process with updates every five years.	River basin water planning process continues.
Wyoming Water Development Commission, 2012, in association with the State Engineer's Office and U.W. Water Resources Data System, 2011 Bear River Basin plan update, final report, technical memoranda, GIS products and hydrologic models: variously paged.					
<u>Town of Bear River (see Northern Uinta County, below)</u>					
Sunrise Engineering, 2005, in association with Fassett Consulting, LLC., Evanston/Bear River regional pipeline level II study: prepared for the Wyoming Water Development Commission, variously paged.	Town of Bear River, Uinta County		Analyses of water rights, infrastructure, regional water supply system facilities and economics. Provide conceptual design and cost estimates and environmental report.	Proposed PWS is capable of serving Town of Bear River and unincorporated areas between Bear River and Evanston. Project will entail significant funding.	

Citation(s)	Location	Aquifer/ Formation	Project Description	Results/Recommendations	Current Status
<u>Cokeville</u>  Johnson-Fermelia Company, Inc., 1991, Phase 1 Report, Cokeville water supply study project level I: prepared for the Wyoming Water Development Commission, variously paged, 6 pl	Town of Cokeville, Lincoln County	Gannett, Smith's Fork, Thomas Fork	Assess the adequacy of the supply springs, and water facilities to meet Cokeville's water supply requirements. Investigate water facilities compliance with SDWA.	Supply springs can meet average daily water supply demands, water facilities require improvements, and source water is not under direct influence of surface water.	N/A
<u>Forsgren Associates, 1993a, Cokeville water supply level II study, final report: prepared for the Wyoming Water Development Commission and the Town of Cokeville, Wyoming, variously paged</u>  <u>Forsgren Associates, 1993b, in association with Chen Northern, Inc., Trihydro Corporation, Cokeville Water Supply Level II Study, Supplemental Reports, Final Report: prepared for the Wyoming Water Development Commission and the Town of Cokeville, Wyoming, variously paged</u>	Lincoln County	Gannett, Smith's Fork, Thomas Fork	Evaluate existing water system components, water supply needs and alternatives. Complete 3 test wells. Generate conceptual designs and cost estimates for system improvements	Replace springs with shallow well. Modify delivery system. Institute water conservation program. Obtain Level III funding for Cokeville Test well No. 1 near Cokeville /Kenyon Springs.	N/A
<u>Evanston</u>  Sunrise Engineering, 1997, Evanston water system master plan level II study: prepared for the Wyoming Water Development Commission, variously paged.	City of Evanston	Bear River Alluvium	Evaluate existing water supply and system facilities, water supply needs and alternatives for the City of Evanston.	City's groundwater wells reserved for emergency use, surface water meets supply requirements. Institute regular maintenance program for water infrastructure. Explore development of raw water irrigation system.	

Citation(s)	Location	Aquifer/ Formation	Project Description	Results/Recommendations	Current Status
<u>Northern Uinta County</u>					
Forsgren Associates, 2000, North Uinta County Improvement and Service District water supply master plan level I, final report: prepared for the Wyoming Water Development Commission, variously paged.	Northern Uinta County	Bear River alluvium, Fowkes, Wasatch, Evanston and Bear River formations	Level I study to “examine the feasibility and costs to expand the water system in the area of North Uinta County I&S District.	Construct test well at Deer Mountain subdivision, continue regional PWS investigation, seek funding, negotiate water service agreement with City of Evanston.	
TriHydro Corporation, 2000, in association with Forsgren Associates, Hydrogeologic report, North Uinta County Improvement and Service District water supply master plan: prepared for the Wyoming Water Development Commission and the North Uinta County Improvement and Service District, variously paged.			Level II status report to evaluate the hydrogeology of aquifer, determine depth to groundwater and aquifer thickness, complete and test new test well, and assess groundwater quality.	Deer Mountain #6 test well in Wasatch formation was completed, developed and tested for aquifer hydraulics and water quality. Level III design and construction should proceed to connect Deer Mountain #6 test well to PWS.	
TriHydro Corporation, 2003, in association with Forsgren Associates, North Uinta water supply project level II feasibility study, Bear River, Wyoming, final report: prepared for the Wyoming Water Development Commission and the North Uinta County Improvement and Service District, variously paged.					
<u>Current WWDC Bear River Basin Projects</u>					
Bear River Basin Groundwater Analysis WSGS Bear River Hydrology Model WWDC					
Black & Veatch, 1983, Water Supply Needs Assessment for the North Platte and Little Snake River Drainages Phase I, Vols. 1,2: prepared for the Wyoming Water Development Commission, variously paged.	North Platte and Little Snake River Drainages	N/A	Phase I, Volumes I & II, analysis of the water supply needs of various communities located within the North Platte and Little Snake River Conservation District.	There is the possibility to develop enough water to meet both in basin and out of basin needs for the near future	Continue with Phase II of the Water Supply Needs Analysis.

# Appendix C

*Dataset Sources for  
Figures and Plates*

Dataset	Presented in	Source
<b>GEOLOGY</b>		
		Modified from Vuke, Porter, et al., 2007 Love, J.D.,
Bear River Basin geology	Plate 1, various figures	Christiansen, A.C., 1985
Precambrian basement structure		
contour	Plate 1	Modified from Blackstone, 1993
Precambrian basement faults	Plate 1	Modified from Blackstone, 1993
BRB cross-section lines	Plate 1	WSGS
BRB Lineaments	Plate 1	Cooley, M. E., 1986
		Vuke, Porter, et al., 2007 Love, J.D., Christiansen, A.C.,
BRB faults, Wyoming	Plate 1	1985
		Vuke, Porter, et al., 2007 Love, J.D., Christiansen, A.C.,
BRB faults, Utah	Plate 1	1985
Hydrogeology (includes aquifer out-	Plate 2, Figures 6-1,	
crop areas)	6-2, 6-3, 6-4	T. Bartos, USGS, 2013
Thrust Sheets	Figure 4-1	Modified from Royse, F., Jr., 1993
<b>GROUNDWATER</b>		
Aquifer recharge as a percent of pre-		Modified from Hamerlinck and Arneson, 1998, and
cipitation	Figure 6-5	Daly and Taylor, 1998
Aquifer sensitivity	Figure 5-3	Hamerlinck and Arneson, 1998
Average annual precipitation, 1981-		
2010	Figure 3-3	PRISM Climate Group, Oregon State University
Environmental water sample locations		USGS, Environmental water sample locations GIS
Estimated net annual aquifer recharge	Figure 5-2	dataset of 2010
Produced water sample locations		Hamerlinck and Arneson, 1998
Springs		WOGCC, Produced water database, 2009
SWAP locations	Figure 5-11	Stafford and Gracias, WSGS, 2009
WWDC potential groundwater devel-		Modified from Trihydro Corporation, 2004
opment areas		Digitized from BRS, Inc., 2003e
		Wyoming State Engineer's Office, 2012 Idaho De-
	Figures 8-1, 8-2, 8-3,	partment of Water Resources, 2012, Utah Division of
Permitted wells	8-4, 8-5, 8-6	Water Rights, 2012

Dataset	Presented in	Source
<b>POTENTIAL GROUNDWATER CONTAMINANTS</b>		
		Created from WDEQ Abandoned Mine Land table of 2010
Abandoned mine sites	Figure 5-7	
Active coal mine	Figure 5-8	WDEQ, Land Quality Division, 2012
Active disposal and injection wells	Figure 5-4	Modified from WOGCC well header data as of 2009
Small, Limited, and Regular Mining		
Permits	Figure 5-8	WDEQ LQD, 2012
Non Coal Mines	Figure 5-8	WDEQ LQD, 2011
		Modified from WDEQ Solid and Hazardous Waste Division (SHWD) storage tank table of 2009
Storage tanks	Figure 5-10	
Active Wyoming Pollutant Discharge Elimination System (WYPDES)		WDEQ Water Quality Division (WQD) WYPDES GIS dataset of 2009
outfalls	Figure 5-6	WDEQ/WQD commercial oil and gas disposal pit GIS dataset of 2012
Commercial oil and gas disposal pits	Figure 5-6	WDEQ/WQD Groundwater Program known contaminated areas GIS dataset of 2012
Pollution Control Facilities	Figure 5-6	De Bruin, 2007
Oil and gas fields	Figure 5-4	Wyoming Pipeline Authority
Pipelines	Figure 5-4	Modified from WDEQ SHWD solid and hazardous waste facilities table of 2009
Solid and hazardous waste facilities	Figure 5-10	Modified from WDEQ/WQD UIC GIS dataset of 2009
Underground Injection Control (UIC)		
Class I and V wells	Figure 5-5	
Voluntary Remediation Program (VRP) sites	Figure 5-10	Modified from WDEQ SHWD VRP tables and GIS datasets of 2009
WSGS mines, pits, mills, and plants	Figure 5-9	Harris, 2004
<b>BASE DATA</b>		
		Modified from USGS National Hydrography Dataset
Basin boundary	Plate 1, various figures	hydrologic units
Elevation	Plate 1, various figures	Modified from U.S. Geological Survey, 1999
Hillshade	Plate 1, various figures	USGS, 1999
Lakes	Plate 1, various figures	USGS, National Hydrologic Dataset
Rivers	Plate 1, various figures	USGS, National Hydrologic Dataset
		U.S. Department of Commerce, U.S. Census Bureau, Geography Division, 2010
Wyoming state boundary	Plate 1, various figures	

Dataset	Presented in	Source
Utah state boundary	Plate 1, various figures	U.S. Department of Commerce, U.S. Census Bureau, Geography Division, 2010
Idaho state boundary	Plate 1, various figures	U.S. Department of Commerce, U.S. Census Bureau, Geography Division, 2010
Wyoming counties	Plate 1, various figures	U.S. Department of Commerce, U.S. Census Bureau, Geography Division, 2010
Utah counties	Plate 1, various figures	U.S. Department of Commerce, U.S. Census Bureau, Geography Division, 2010
Idaho counties	Plate 1, various figures	Geography Division, 2010
Wyoming townships	Plate 1, various figures	Premier Data Services, 2008
Utah townships	Plate 1, various figures	Premier Data Services, 2009
Idaho townships	Plate 1, various figures	Bureau of Land Management
Mountain peaks	Physiographic features figure	WSGS, unpublished mountain peaks GIS dataset of 2008 U.S. Department of Commerce, U.S. Census Bureau,
Wyoming roads	Plate 1, various figures	Geography Division, 2010 U.S. Department of Commerce, U.S. Census Bureau,
Utah roads	Plate 1, various figures	Geography Division, 2010 U.S. Department of Commerce, U.S. Census Bureau,
Idaho roads	Plate 1, various figures	Geography Division, 2010
BRB Towns	Plate 1, various figures	NAUS, 2003

# Appendix D

*Amended Bear River  
Compact, 1978*

## AMENDED BEAR RIVER COMPACT, 1978

<u>Signatory States:</u>	Idaho, Utah and Wyoming
<u>Rivers Controlled:</u>	Bear River and its tributaries
<u>Ratifications:</u>	<p>Wyo. Stat. Ann. §41-12-101 (2005) [Act of March 6, 1979, 1979 Wyo. Sess. Laws, ch.151, p. 337]</p> <p>Idaho Code §42-3402 (2003) [Act of April 5, 1979, 1979 Idaho Sess. Laws, ch. 322, p. 862]</p> <p>Utah Code Ann. §73-16-2 (2005) [Act of May 8, 1979, 1979 Utah Laws, ch.254, p. 1213]</p>
<u>Summary:</u>	<p>The Compact becomes operative only when an emergency is found to exist as provided for by the terms of the Compact. When an emergency is declared, the Compact regulates the river by creating three divisions: Upper, Central, and Lower. Water administration becomes effective to diversions by section in the Upper Division; by percentage between the States of Wyoming and Idaho in the Central Division; and by priority for rights in the Lower Division.</p> <p>The Compact also apportions storage rights in the Bear River Basin above Stewart Dam and allocates increases in depletion from the Bear River and its tributaries, including ground water tributary to the Bear River, which occur on or after January 1, 1976, among the states. Each state is allowed the use of water, including ground water, for ordinary domestic and stock watering purposes including the right to impound water for such purposes in reservoirs having capacities not in excess of 20 acre-feet without deduction from the allocation made in the Compact.</p>

## AMENDED BEAR RIVER COMPACT, 1978

The State of Idaho, the State of Utah, and the State of Wyoming, acting through their respective commissioners after negotiations participated in by a representative of the United States of America appointed by the president, have agreed to an amended Bear River Compact as follows:

### ARTICLE I

- A. The major purposes of this compact are to remove the causes of present and future controversy over the distribution and use of the waters of the Bear River; to provide for efficient use of water for multiple purposes; to permit additional development of the water resources of Bear River; to promote interstate comity; to accomplish an equitable apportionment of the waters of the Bear

River among the compacting states.

- B. The physical and all other conditions peculiar to the Bear River constitute the basis for this compact. No general principle or precedent with respect to any other interstate stream is intended to be established.

## ARTICLE II

As used in this compact the term -

1. "Bear River" means the Bear River and its tributaries from its source in the Uinta Mountains to its mouth in Great Salt Lake
2. "Bear Lake" means Bear Lake and Mud Lake
3. "Upper Division" means the portion of Bear River from its source in the Uinta Mountains to and including Pixley Dam, a diversion dam in the southeast quarter of Section 25, Township 23 North, Range 120 West, Sixth Principal Meridian, Wyoming;
4. "Central Division" means the portion of the Bear River from Pixley Dam to and including Stewart Dam, a diversion dam in Section 34, Township 13 South, Range 44 East, Boise Base and Meridian, Idaho;
5. "Lower Division," means the portion of the Bear River between Stewart Dam and Great Salt Lake, including Bear Lake and its tributary drainage
6. "Upper Utah Section Diversions" means the sum of all diversions in second-feet from the Bear River and the tributaries of Bear River joining the Bear River upstream from the point where the Bear River crosses the Utah-Wyoming state line above Evanston, Wyoming, excluding the diversions by the Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal;
7. "Upper Wyoming Section Diversions" means the sum of all diversions in second-feet from the Bear River main stem from the point where the Bear River crosses the Utah-Wyoming state line above Evanston, Wyoming, to the point where the Bear River crosses the Wyoming-Utah state line east of Woodruff, Utah, and including the diversions by the Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal;
8. "Lower Utah section diversions" means the sum of all diversions in second-feet from the Bear River main stem from the point where the Bear River crosses the Wyoming-Utah state line east of Woodruff, Utah, to the point where the Bear River crosses the Utah-Wyoming state line northeast of Randolph, Utah;
9. "Lower Wyoming Section Diversions" means the sum of all diversions in second-feet from the Bear River main stem from the point where the Bear River crosses the Utah-Wyoming state line northeast of Randolph to and including the diversion at Pixley Dam;
10. "Commission" means the Bear River Commission, organized pursuant to Article III of this Compact;
11. "Water user" means a person, corporation, or other entity having a right to divert water from the Bear River for beneficial use
12. "Second-foot" means a flow of one cubic foot of water per second of time passing a given point
13. "Acre-foot" means the quantity of water required to cover one acre to a depth of one foot, equivalent to 43,560 cubic feet
14. "Biennium" means the 2-year period commencing on October 1 of the first odd numbered year after the effective date of this compact and each 2-year period thereafter;

15. "Water year," means the period beginning October 1 and ending September 30 of the following year
16. "Direct flow" means all water flowing in a natural watercourse except water released from storage or imported from a source other than the Bear River watershed
17. "Border Gaging Station" means the stream flow gauging station in Idaho on the Bear River above Thomas Fork near the Wyoming-Idaho boundary line in the northeast quarter of the northeast quarter of Section 15, Township 14 South, Range 46 East, Boise Base and Meridian, Idaho;
18. "Smiths Fork" means a Bear River tributary, which rises in Lincoln County, Wyoming and flows in a general southwesterly direction to its confluence with Bear River near Cokeville, Wyoming
19. "Grade Creek" means a Smiths Fork tributary that rises in Lincoln County, Wyoming and flows in a westerly direction and in its natural channel is tributary to Smiths Fork in Section 17, Township 25 North, Range 118 West, Sixth Principal Meridian, Wyoming;
20. "Pine Creek" means a Smiths Fork tributary which rises in Lincoln County, Wyoming, emerging from its mountain canyon in Section 34, Township 25 North, Range 118 West, Sixth Principal Meridian, Wyoming, and in its natural channel is tributary to Smiths Fork in Section 36, Township 25 North, Range 119 West, Sixth Principal Meridian, Wyoming;
21. "Bruner Creek" and "Pine Creek Springs" means Smiths Fork tributaries which rise in Lincoln County, Wyoming, in Sections 31 and 32, Township 25 North, Range 118 West, Sixth Principal Meridian, and in their natural channels are tributary to Smiths Fork in Section 36, Township 25 North, Range 119 West, Sixth Principal Meridian, Wyoming;
22. "Spring Creek" means a Smiths Fork tributary which rises in Lincoln County, Wyoming, in Sections 1 and 2, Township 24 North, Range 119 West, Sixth Principal Meridian, Wyoming, and flows in a general westerly direction to its confluence with Smiths Fork in Section 4, Township 24 North, Range 119 West, Sixth Principal Meridian, Wyoming;
23. "Sublette Creek" means the Bear River tributary, which rises in Lincoln County, Wyoming and flows in a general westerly direction to its confluence with Bear River in Section 20, Township 24 North, Range 119 West, Sixth Principal Meridian, Wyoming;
24. "Hobble Creek" means the Smiths Fork tributary, which rises in Lincoln County, Wyoming and flows in a general southwesterly direction to its confluence with Smiths Fork in Section 35, Township 28 North, Range 118 West, Sixth Principal Meridian, Wyoming;
25. "Hilliard East Fork Canal" means that irrigation canal which diverts water from the right bank of the East Fork of Bear River in Summit County, Utah, at a point west 1,310 feet and north 330 feet from the southeast corner of Section 16, Township 2 North, Range 10 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah-Wyoming state line into the southwest quarter of Section 21, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;
26. "Lannon Canal" means that irrigation canal which diverts water from the right bank of the Bear River in Summit County, Utah, east 1,480 feet from the west quarter corner of Section 19, Township 3 North, Range 10 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah-Wyoming state line into the south half of Section 20, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;
27. "Lone Mountain Ditch" means that irrigation canal which diverts water from the right bank of the

Bear River in Summit County, Utah, north 1,535 feet and east 1,120 feet from the west quarter corner of Section 19, Township 3 North, Range 10 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah-Wyoming state line into the south half of Section 20, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;

28. "Hilliard West Side Canal" means that irrigation canal which diverts water from the right bank of the Bear River in Summit County, Utah, at a point north 2,190 feet and east 1,450 feet from the south quarter corner of Section 13, Township 3 North, Range 9 East, Salt Lake Base and Meridian, Utah, and runs in a northerly direction crossing the Utah-Wyoming state line into the south half of Section 20, Township 12 North, Range 119 West, Sixth Principal Meridian, Wyoming;
29. "Francis Lee Canal" means that irrigation canal which diverts water from the left bank of the Bear River in Uinta County, Wyoming, in the northeast quarter of Section 30, Township 18 North, Range 120 West, Sixth Principal Meridian, Wyoming, and runs in a westerly direction across the Wyoming-Utah state line into Section 16, Township 9 North, Range 8 East, Salt Lake Base and Meridian, Utah;
30. "Chapman Canal" means that irrigation canal which diverts water from the left bank of the Bear River in Uinta County, Wyoming, in the northeast quarter of Section 36, Township 16 North, Range 121 West, Sixth Principal Meridian, Wyoming, and runs in a northerly direction crossing over the low divide into the Saleratus drainage basin near the southeast corner of Section 36, Township 17 North, Range 121 West, Sixth Principal Meridian, Wyoming and then in a general westerly direction crossing the Wyoming-Utah state line;
31. "Neponset Reservoir" means that reservoir located principally in Sections 34 and 35, Township 8 North, Range 7 East, Salt Lake Base and Meridian, Utah, having a capacity of 6,900 acre-feet.

### ARTICLE III

- A. There is hereby created an interstate administrative agency to be known as the "Bear River Commission" which is hereby constituted a legal entity and in such name shall exercise the powers hereinafter specified. The commission shall be composed of nine commissioners, three commissioners representing each signatory state, and if appointed by the president, one additional commissioner representing the United States of America who shall serve as chairman, without vote. Each commissioner, except the chairman, shall have one vote. The state commissioners shall be selected in accordance with state law. Six commissioners who shall include two commissioners from each state shall constitute a quorum. The vote of at least two-thirds of the commissioners when a quorum is present shall be necessary for the action of the commission.
- B. The compensation and expenses of each commissioner and each adviser shall be paid by the government which he represents. All expenses incurred by the commission in the administration of this compact, except those paid by the United States of America, shall be paid by the signatory states on an equal basis.
- C. The Commission shall have power to:
  1. Adopt by-laws, rules, and regulations not inconsistent with this compact;
  2. Acquire, hold, convey or otherwise dispose of property;
  3. Employ such persons and contract for such services as may be necessary to carry out its

duties under this compact;

4. Sue and be sued as a legal entity in any court of record of a signatory state, and in any court of the United States having jurisdiction of such action;
5. Cooperate with state and federal agencies in matters relating to water pollution of interstate significance;
6. Perform all functions required of it by this compact and do all things necessary, proper or convenient in the performance of its duties hereunder, independently or in cooperation with others, including state and federal agencies.

D. The commission shall:

1. Enforce this compact and its orders made hereunder by suit or other appropriate action
2. Compile a report covering the work of the commission and expenditures during the current biennium, and an estimate of expenditures for the following biennium and transmit it to the President of the United States and to the Governors of the signatory states on or before July 1 following each biennium.

#### ARTICLE IV

Rights to direct flow water shall be administered in each signatory state under state law, with the following limitations:

A. When there is a water emergency, as hereinafter defined for each division, water shall be distributed therein as provided below.

1. Upper Division

a. When the divertible flow as defined below for the Upper Division is less than 1,250 second-feet, a water emergency shall be deemed to exist therein and such divertible flow is allocated for diversion in the river sections of the Division as follows:

Upper Utah Section Diversions - 0.6 percent, Upper Wyoming Section Diversions - 49.3 percent, Lower Utah Section Diversions - 40.5 percent, Lower Wyoming Section Diversions - 9.6 percent.

Such divertible flow shall be the total of the following five items:

- (1) Upper Utah Section Diversions in second-feet,
- (2) Upper Wyoming Section Diversions in second-feet,
- (3) Lower Utah Section Diversions in second-feet,
- (4) Lower Wyoming Section Diversions in second-feet,
- (5) The flow in second-feet passing Pixley Dam.

b. The Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal, which divert water in Utah to irrigate lands in Wyoming, shall be supplied from the divertible flow allocated to the Upper Wyoming Section Diversions.

c. The Chapman, Bear River, and Francis Lee Canals, which divert water from the main stem of Bear River in Wyoming to irrigate lands in both Wyoming and Utah, shall be supplied from the divertible flow allocated to the Upper Wyoming Section Diversions.

d. The Beckwith Quinn West Side Canal, which diverts water from the main stem of Bear River in Utah to irrigate lands in both Utah and Wyoming, shall be supplied from the divertible flow allocated to the Lower Utah Section Diversions.

e. If for any reason the aggregate of all diversions in a river section of the upper Division does not equal the allocation of water thereto, the unused portion of such allocation shall be

available for use in the other river sections in the Upper Division in the following order: (1) in the other river section of the same State in which the unused allocation occurs; and (2) in the river sections of the other State. No permanent right of use shall be established by the distribution of water pursuant to this paragraph e.

- f. Water allocated to the several sections shall be distributed in each section in accordance with state law.

## 2. Central Division

- a. When either the divertible flow as hereinafter defined for the Central Division is less than 870 second-feet, or the flow of the Bear River at Border Gaging Station is less than 350 second-feet, whichever shall first occur, a water emergency shall be deemed to exist in the Central Division and the total of all diversions in Wyoming from Grade Creek, Pine Creek, Bruner Creek and Pine Creek Springs, Spring Creek, Sublette Creek, Smiths Fork, and all the tributaries of Smiths Fork above the mouth of Hobble Creek including Hobble Creek, and from the main stem of the Bear River between Pixley Dam and the point where the river crosses the Wyoming-Idaho state line near Border shall be limited for the benefit of the State of Idaho, to not exceeding forty-three (43) percent of the divertible flow. The remaining fifty-seven (57) percent of the divertible flow shall be available for use in Idaho in the Central Division, but if any portion of such allocation is not used therein, it shall be available for use in Idaho in the Lower Division.

The divertible flow for the Central Division shall be the total of the following three items:

- (1) Diversions in second-feet in Wyoming consisting of the sum of all diversions from Grade Creek, Pine Creek, Bruner Creek and Pine Creek Springs, Spring Creek, Sublette Creek, and Smiths Fork and all the tributaries of Smiths Fork above the mouth of Hobble Creek including Hobble Creek, and the main stem of the Bear River between Pixley Dam and the point where the river crosses the Wyoming-Idaho state line near Border, Wyoming.
- (2) Diversions in second-feet in Idaho from the Bear River main stem from the point where the river crosses the Wyoming-Idaho state line near Border to Stewart Dam including West Fork Canal, which diverts at Stewart Dam.
- (3) Flow in second-feet of the Rainbow Inlet Canal and of the Bear River passing downstream from Stewart Dam.
  - b. The Cook Canal, which diverts water from the main stem of the Bear River in Wyoming to irrigate lands in both Wyoming and Idaho, shall be considered a Wyoming diversion and shall be supplied from the divertible flow allocated to Wyoming.
  - c. Water allocated to each state shall be distributed in accordance with state law.

## 3. Lower Division

- a. When the flow of water across the Idaho-Utah boundary line is insufficient to satisfy water rights in Utah, covering water applied to beneficial use prior to January 1, 1976, any water user in Utah may file a petition with the Commission alleging that by reason of diversions in Idaho he is being deprived of water to which he is justly entitled, and that by reason thereof, a water emergency exists, and requesting distribution of water under the direction of the Commission. If the Commission finds a water emergency exists, it shall put into effect water delivery schedules based on priority of rights and prepared by the Commission without regard to the boundary line for all or any part of the Division, and during such emergency,

water shall be delivered in accordance with such schedules by the state official charged with the administration of public waters.

- B. The Commission shall have authority upon its own motion (1) to declare a water emergency in any or all river divisions based upon its determination that there are diversions which violate this Compact and which encroach upon water rights in a lower State, (2) to make appropriate orders to prevent such encroachments, and (3) to enforce such orders by action before State administrative officials or by court proceedings.
- C. When the flow of water in an interstate tributary across a state boundary line is insufficient to satisfy water rights on such tributary in a lower State, any water user may file a petition with the Commission alleging that by reason of diversions in an upstream State he is being deprived of water to which he is justly entitled and that by reason thereof a water emergency exists, and requesting distribution of water under the direction of the Commission. If the Commission finds that a water emergency exists and that interstate control of water of such tributary is necessary, it shall put into effect water delivery schedules based on priority of rights and prepared without regard to the State boundary line. The State officials in charge of water distribution on interstate tributaries may appoint and fix the compensation and expenses of a joint water commissioner for each tributary. The proportion of the compensation and expenses to be paid by each State shall be determined by the ratio between the number of acres therein which are irrigated by diversions from such tributary, and the total number of acres irrigated from such tributary.
- D. In preparing interstate water delivery schedules, the Commission, upon notice and after public hearings, shall make findings of fact as to the nature, priority and extent of water rights, rates of flow, duty of water, irrigated acreages, types of crops, time of use, and related matters; provided that such schedules shall recognize and incorporate therein priority of water rights as adjudicated in each of the signatory States. Such findings of fact shall, in any court or before any tribunal, constitute prima facie evidence of the facts found.
- E. Water emergencies provided for herein shall terminate on September 30 of each year unless terminated sooner or extended by the Commission.

#### ARTICLE V

- A. Water rights in the Lower Division acquired under the laws of Idaho and Utah covering water applied to beneficial use prior to January 1, 1976, are hereby recognized and shall be administered in accordance with state law based on priority of rights as provided in Article IV, paragraph A.3. Rights to water first applied to beneficial use on or after January 1, 1976, shall be satisfied from the respective allocations made to Idaho and Utah in this paragraph and the water allocated to each State shall be administered in accordance with State law. Subject to the foregoing provisions, the remaining water in the Lower Division, including ground water tributary to the Bear River, is hereby apportioned for use in Idaho and Utah as follows:
  - (1) Idaho shall have the first right to the use of such remaining water resulting in an annual depletion of not more than 125,000 acre-feet; (2) Utah shall have the second right to the use of such remaining water resulting in an annual depletion of not more than 275,000 acre-feet;
  - (3) Idaho and Utah shall each have an additional right to deplete annually on an equal basis, 75,000 acre-feet of the remaining water after the rights provided by subparagraphs (1), and (2) above have been satisfied;

- (4) Any remaining water in the Lower Division after the allocations provided for in subparagraphs (1), (2), and (3) above have been satisfied shall be divided; thirty (30) percent to Idaho and seventy (70) percent to Utah.
- B. Water allocated under the above subparagraphs shall be charged against the State in which it is used regardless of the location of the point of diversion.
- C. Water depletions permitted under provisions of subparagraphs (1), (2), and (3), and (4) above, shall be calculated and administered by a Commission-approved procedure.

#### ARTICLE VI

- A. Existing storage rights in reservoirs constructed above Stewart Dam prior to February 4, 1955 are as follows:

Idaho ..... 324 acre-feet  
 Utah..... 11,850 acre-feet  
 Wyoming ..... 2,150 acre-feet

Additional rights are hereby granted to store in any water year above Stewart Dam, 35,500 acre-feet of Bear River water and no more under this paragraph for use in Utah and Wyoming; and to store in any water year in Idaho or Wyoming on Thomas Fork 1,000 acre-feet of water for use in Idaho. Such additional storage rights shall be subordinate to, and shall not be exercised when the effect thereof will be to impair or interfere with (1) existing direct flow rights for consumptive use in any river division and (2) existing storage rights above Stewart Dam, but shall not be subordinate to any right to store water in Bear Lake or elsewhere below Stewart Dam. One-half of the 35,500 acre-feet of additional storage right above Stewart Dam so granted to Utah and Wyoming is hereby allocated to Utah, and the remaining one-half thereof is allocated to Wyoming.

- B. In addition to the rights defined in Paragraph A. of this Article, further storage entitlements above Stewart Dam are hereby granted. Wyoming and Utah are granted an additional right to store in any year 70,000 acre-feet of Bear River, water for use in Utah and Wyoming to be divided equally; and Idaho is granted an additional right to store 4,500 acre-feet of Bear River water in Wyoming or Idaho for use in Idaho. Water rights granted under this paragraph and water appropriated, including ground water tributary to Bear River, which is applied to beneficial use on or after January 1, 1976, shall not result in an annual increase in depletion of the flow of the Bear River and its tributaries above Stewart Dam of more than 28,000 acre-feet in excess of the depletion as of January 1, 1976. Thirteen thousand (13,000) acre-feet of the additional depletion above Stewart Dam is allocated to each of Utah and Wyoming, and two thousand (2,000) acre-feet is allocated to Idaho.

The additional storage rights provided for in this paragraph shall be subordinate to, and shall not be exercised when the effect thereof will be to impair or interfere with (1) existing direct flow rights for consumptive use in any river division and (2) existing storage rights above Stewart Dam, but shall not be subordinate to any right to store water in Bear Lake or elsewhere below Stewart Dam; provided, however, there shall be no diversion of water to storage above Stewart Dam under this paragraph B. when the water surface elevation of Bear Lake is below 5,911.00 feet, Utah Power & Light Company datum (the equivalent of elevation 5,913.75 feet based on the sea level datum of 1929 through the Pacific Northwest Supplementary Adjustment of 1947). Water depletions permitted under this paragraph B. shall be calculated and administered by a

Commission-approved procedure.

- C. In addition to the rights defined in Article VI, paragraphs A. and B., Idaho, Utah and Wyoming are granted the right to store and use water above Stewart Dam that otherwise would be bypassed or released from Bear Lake at times when all other direct flow and storage rights are satisfied. The availability of such water and the operation of reservoir space to store water above Bear Lake under this paragraph shall be determined by a Commission-approved procedure. The storage provided for in this paragraph shall be subordinate to all other storage and direct flow rights in the Bear River. Storage rights under this paragraph shall be exercised with equal priority on the following basis: six (6) percent thereof to Idaho; forty-seven (47) percent thereof to Utah; and forty-seven (47) percent thereof to Wyoming.
- D. The waters of Bear Lake below elevation 5,912.91 feet, Utah Power & Light Company Bear Lake datum (the equivalent of elevation 5915.66 feet based on the sea level datum of 1929 through the Pacific Northwest Supplementary Adjustment of 1947) shall constitute a reserve for irrigation. The water of such reserve shall not be released solely for the generation of power, except in emergency, but after release for irrigation, it may be used in generating power if not inconsistent with its use for irrigation. Any water in Bear Lake in excess of that constituting the irrigation reserve may be used for the generation of power or for other beneficial uses. As new reservoir capacity above the Stewart Dam is constructed to provide additional storage pursuant to paragraph A. of this article, the Commission shall make a finding in writing as to the quantity of additional storage and shall thereupon make an order increasing the irrigation reserve in accordance with the following table:

<u>Additional Storage</u> <u>acre-feet</u>	<u>Lake surface elevation</u> <u>Utah Power &amp; Light Company</u> <u>Bear Lake datum</u>
5,000	5,913.24
10,000	5,913.56
15,000	5,913.87
20,000	5,914.15
25,000	5,914.41
30,000	5,914.61
35,500	5,914.69
36,500	5,914.70

- E. Subject to existing rights, each State shall have the use of water, including ground water, for ordinary domestic, and stock watering purposes, as determined by State law and shall have the right to impound water for such purposes in reservoirs having storage capacities not in excess, in any case, of 20 acre-feet, without deduction from the allocation made by paragraphs A., B. and C. of this Article.
- F. The storage rights in Bear Lake are hereby recognized and confirmed subject only to the restrictions hereinbefore recited.

#### ARTICLE VII

It is the policy of the signatory States to encourage additional projects for the development of the water

resources of the Bear River to obtain the maximum beneficial use of water with a minimum of waste, and in furtherance of such policy, authority is granted within the limitations provided by this Compact, to investigate, plan, construct, and operate such projects without regard to state boundaries, provided that water rights for each such project shall, except as provided in Article VI, paragraphs A. and B. thereof, be subject to rights theretofore initiated and in good standing.

#### ARTICLE VIII

- A. No state shall deny the right of the United States of America, and subject to the conditions hereinafter contained, no state shall deny the right of another signatory state, any person or entity of another signatory state, to acquire rights to the use of water or to construct or to participate in the construction and use of diversion works and storage reservoirs with appurtenant works, canals, and conduits in one state for use of water in another state, either directly or by exchange. Water rights acquired for out-of-state use shall be appropriated in the state where the point of diversion is located in the manner provided by law for appropriation of water for use within such state.
- B. Any signatory state, any person or any entity of any signatory state, shall have the right to acquire in any other signatory state such property rights as are necessary to the use of water in conformity with this Compact by donation, purchase, or, as hereinafter provided through the exercise of the power of eminent domain in accordance with the law of the state in which such property is located. Any signatory state, upon the written request of the governor of any other signatory state for the benefit of whose water users property is to be acquired in the state to which such written request is made, shall proceed expeditiously to acquire the desired property either by purchase at a price acceptable to the requesting governor, or if such purchase cannot be made, then through the exercise of its power of eminent domain and shall convey such property to the requesting state or to the person, or entity designated by its governor provided, that all costs of acquisition and expenses of every kind and nature whatsoever incurred in obtaining such property shall be paid by the requesting state or the person or entity designated by its governor.
- C. Should any facility be constructed in a signatory state by and for the benefit of another signatory state or persons or entities therein, as above provided, the construction, repair, replacement, maintenance and operation of such facility shall be subject to the laws of the state in which the facility is located.
- D. In the event lands or other taxable facilities are acquired by a signatory state in another signatory state for the use and benefit of the former, the users of the water made available by such facilities, as a condition precedent to the use thereof, shall pay to the political subdivisions of the state in which such facilities are located, each and every year during which such rights are enjoyed for such purposes, a sum of money equivalent to the average of the amount of taxes annually levied and assessed against the land and improvements thereon during the ten years preceding the acquisition of such land. Said payments shall be in full reimbursement for the loss of taxes in such political subdivision of the state.
- E. Rights to the use of water acquired under this Article shall in all respects be subject to this Compact.

#### ARTICLE IX

Stored water, or water from another watershed may be turned into the channel of the Bear River in one

state and a like quantity, with allowance for loss by evaporation, transpiration, and seepage, may be taken out of the Bear River in another state either above or below the point where the water is turned into the channel, but in making such exchange the replacement water shall not be inferior in quality for the purpose used or diminished in quantity. Exchanges shall not be permitted if the effect thereof is to impair vested rights or to cause damage for which no compensation is paid. Water from another watershed or source, which enters the Bear River by actions within a state, may be claimed exclusively by that state and use thereof by that state shall not be subject to the depletion limitations of Articles IV, V and VI. Proof of any claimed increase in flow shall be the burden of the State making such claim, and it shall be approved only by the unanimous vote of the Commission.

#### ARTICLE X

- A. The following rights to the use of Bear River water carried in interstate canals are recognized and confirmed.

Name of Canal	Date of Priority	Primary right second –feet	<u>Lands Irrigated</u>	
			Acres	State
Hilliard East Fork	1914	28.00	2,644	Wyoming
Chapman	8-13-86	16.46	1,155	Wyoming
	8-13-86	98.46	6,892	Utah
	4-12-12	.57	40	Wyoming
	5- 3-12	4.07	285	Utah
	5-21-12	10.17	712	Utah
	2- 6-13	.79	55	Wyoming
	8-28-05	<sup>1</sup> 134.00		
Francis Lee	1879	2.20	154	Wyoming
	1879	7.41	519	Utah

<sup>1</sup> Under the right as herein confirmed not to exceed 134 second-feet may be carried across the Wyoming-Utah state line in the Chapman Canal at any time for filling the Neponset Reservoir, for irrigation of land in Utah and for other purposes. The storage right in Neponset Reservoir is for 6,900 acre-feet, which is a component part of the irrigation right for the Utah lands listed above.

All other rights to the use of water carried in interstate canals and ditches, as adjudicated in the State in which the point of Diversion is located, are recognized and confirmed.

- B. All interstate rights shall be administered by the State in which the point of diversion is located and during times of water emergency, such rights shall be filled from the allocations specified in Article IV hereof for the section in which the point of diversion is located, with the exception

that the diversion of water into the Hilliard East Fork Canal, Lannon Canal, Lone Mountain Ditch, and Hilliard West Side Canal shall be under the administration of Wyoming. During times of water emergency, these canals and the Lone Mountain Ditch shall be supplied from the allocation specified in Article IV for the Upper Wyoming Section Diversions.

#### ARTICLE XI

Applications for appropriation, for change of point of diversion, place and nature of use, and for exchange of Bear River water shall be considered and acted upon in accordance with the law of the state in which the point of diversion is located, but no such application shall be approved if the effect thereof will be to deprive any water user in another state of water to which he is entitled, nor shall any such application be approved if the effect thereof will be an increase in the depletion of the flow of the Bear River and its tributaries beyond the limits authorized in each State in Articles IV, V and VI of this Compact. The official of each state in charge of water administration shall, at intervals and in the format established by the Commission, report on the status of use of the respective allocations.

#### ARTICLE XII

Nothing in this compact shall be construed to prevent the United States, a signatory state or political subdivision thereof, person, corporation, or association, from instituting or maintaining any action or proceeding, legal or equitable, for the protection of any right under state or federal law or under this Compact.

#### ARTICLE XIII

Nothing contained in this Compact shall be deemed:

1. To affect the obligations of the United States of America to the Indian tribes;
2. To impair, extend or otherwise affect any right or power of the United States, its agencies or instrumentalities involved herein; nor the capacity of the United States to hold or acquire additional rights to the use of the water of the Bear River;
3. To subject any property or rights of the United States to the laws of the States which were not subject thereto prior to the date of this Compact;
4. To subject any property of the United States to taxation by the states or any subdivision thereof, nor to obligate the United States to pay any state or subdivision thereof for loss of taxes.

#### ARTICLE XIV

At intervals not exceeding twenty years, the Commission shall review the provisions hereof, and after notice and public hearing, may propose amendments to any such provision, provided, however, that the provisions contained herein shall remain in full force and effect until such proposed amendments have been ratified by the legislatures of the signatory States and consented to by Congress.

#### ARTICLE XV

This Compact may be terminated at any time by the unanimous agreement of the signatory states. In the event of such termination, all rights established under it shall continue unimpaired.

#### ARTICLE XVI

Should a court of competent jurisdiction hold any part of this Compact to be contrary to the constitution of any signatory State or to the Constitution of the United States, all other severable provisions of this Compact shall continue in full force and effect.

## ARTICLE XVII

This Compact shall be in effect when it shall have been ratified by the legislature of each signatory state and consented to by the Congress of the United States of America. Notice of ratification by the legislature of the signatory states shall be given by the governor of each signatory state to the governor of each of the other signatory states and to the President of the United States of America, and the President is hereby requested to give notice to the governor of each of the signatory states of approval by the Congress of the United States of America.

IN WITNESS WHEREOF, the Commissioners and their advisers have executed this Compact in five originals, one of which shall be deposited with the General Services Administration of the United States of America, one of which shall be forwarded to the governor of each of the signatory states, and one of which shall be made a part of the permanent records of the Bear River Commission.

Done at Salt Lake City, Utah, this 22nd day of December 1978.

For the State of Idaho:  
CLIFFORD J. SKINNER  
J. DANIEL ROBERTS  
DON W. GILBERT

For the State of Utah:  
S. PAUL HOLMGREN  
SIMEON WESTON  
DANIEL F. LAWRENCE

For the State of Wyoming:  
GEORGE L. CHRISTOPULOS  
J. W. MYERS  
JOHN A. TEICHERT

Approved:  
WALLACE N. JIBSON  
Representative of the United States of America  
Attest:  
DANIEL F. LAWRENCE  
Secretary of the Bear River Compact Commission

## NOTES

Congressional Consent to Negotiations. --- By the Act of July 24, 1946, (60 Stat. 658), the Congress gave its consent to the negotiation by the States of Idaho, Utah, and Wyoming of a compact “providing for an equitable division and apportionment among the said States of the waters of the Bear River and all of its tributaries in the three States \*\*\*.” This consent was given “upon condition that one suitable person from the Department of the Interior, who shall be appointed by the President of the United States, shall participate in said negotiations as the representative of the United States and shall make report to Congress of the proceedings and of any compact entered into.” The Act cited also provided that no such compact should be effective until it had been ratified by the legislature of each of the states and “approved” by the Congress.

Congressional Consent to the Compact. --- The Compact set out above is an amended Compact. Consent to the original Compact was given in the Act of March 17, 1958 (72 Stat. 38). The remaining sections of this act read as follows:

SEC. 2. All officers, agencies, departments, and persons of and in the United States Government shall cooperate with the Bear River Commission, established pursuant to the compact consented to hereby, in any manner authorized by law other than this Act, it being the purpose of Congress: that the United States Government shall assist in the furtherance of the objectives of a Bear River Compact and in the work of the commission created thereby.

SEC. 3. Any modification of the allocation of storage rights contained in Article V shall become effective only when consented to by the Congress.

SEC. 4. The right to alter, amend, or repeal this Act is expressly reserved. Consent to the Amended Compact was given in the Act of February 8, 1980, (94 Stat. 4) from which the text of the Compact set out above is taken.

Legislative History of the Compact. --- For legislative history of the original Compact, see SI086, and HR 4647, HR 5379, HR 6381, 15th Congress; House Report 1375 (Committee on Interior and Insular Affairs) and Senate Report 843 (Committee on Interior and Insular Affairs), 85<sup>th</sup> Congress; Congressional Record, vols. 103 and 104.

For legislative history of the Amended Compact, see S1489, and HR 4320, 96<sup>th</sup> Congress; House Report 96-524 (Committee on Interior and Insular Affairs) and Senate Report 96-526 (Committee on the Judiciary), 96<sup>th</sup> Congress; Congressional Record vols. 125 and 126.



# Appendix E

*Environmental Water  
Samples*

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming. –

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{CaCO}_3$ , calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Quaternary alluvial aquifers	Dissolved oxygen	0.10	0.10	0.75	4.0	5.0	6
	pH (standard units)	7.1	7.4	7.5	7.7	8.3	39
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	365	592	724	1,060	2,610	39
	Hardness (as $\text{CaCO}_3$ )	152	270	320	390	980	29
	Calcium	41.0	64.0	76.0	88.0	150	29
	Magnesium	12.0	23.0	32.0	46.0	150	29
	Sodium	3.5	20.0	39.0	74.0	240	29
	Potassium	0.70	1.4	1.7	3.2	6.6	20
	Sodium adsorption ratio (unitless)	0.10	0.40	0.75	1.5	2.8	18
	Alkalinity (as $\text{CaCO}_3$ )	157	228	297	324	502	29
	Chloride	3.0	13.0	32.2	84.0	290	29
	Fluoride	0.10	0.12	0.30	0.35	1.0	20
	Silica	7.9	12.0	16.0	18.0	26.0	21
	Sulfate	7.2	29.0	52.0	110	700	29
	Total dissolved solids	212	354	458	540	1,770	29
	Ammonia (as N)	--	0.01	0.02	0.02	0.04	13
	Nitrate plus nitrite (as N)	--	0.15	0.89	2.3	59.2	18
	Nitrate (as N)	--	0.06	0.30	1.4	17.0	26
	Nitrite (as N)	--	0.001	0.002	0.005	0.03	16
	Orthophosphate (as P)	--	0.01	0.02	0.02	0.03	13
	Phosphorus, unfiltered	0.03	--	--	--	0.04	2
	Arsenic	--	--	--	--	2.0	3
	Barium	25.0	--	350	--	460	3
	Boron	--	50.0	70.0	90.0	250	9
	Cadmium	--	--	--	--	<1.0	3
	Copper	--	--	--	--	<10.0	3
	Iron	--	1.5	9.0	30.0	7,400	14
	Iron, unfiltered	--	8.0	28.0	54.8	6,400	14
	Lead	--	--	--	--	4.0	3
	Manganese	--	0.25	0.91	3.3	63.0	11
	Manganese, unfiltered	160	--	--	--	--	1
	Mercury	--	--	--	--	2.1	3
	Nickel	--	--	--	--	<30.0	3
	Selenium	--	--	--	--	<5.0	5
	Silver	--	--	--	--	<1.0	3
	Zinc	5.0	--	20.0	--	40.0	3
Quaternary terrace-deposit aquifers	pH (standard units)	7.4	7.5	7.7	7.7	8.6	10
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	516	601	827	1,010	1,540	10
	Hardness (as $\text{CaCO}_3$ )	262	300	326	342	410	10
	Calcium	49.0	60.0	67.0	81.0	84.0	10

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO<sub>3</sub>, calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisitic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Quaternary terrace-deposit aquifers—Continued	Magnesium	22.0	26.0	39.5	43.0	66.0	10
	Sodium	8.1	9.6	52.0	77.0	200	10
	Potassium	0.80	--	1.8	--	2.6	3
	Sodium adsorption ratio (unitless)	0.20	0.21	0.70	1.7	4.5	7
	Alkalinity (as CaCO <sub>3</sub> )	202	209	262	285	316	10
	Chloride	5.7	10.0	51.0	90.0	130	10
	Fluoride	0.20	--	0.30	--	0.90	3
	Silica	11.0	14.0	17.5	24.0	30.0	4
	Sulfate	52.0	52.0	75.0	100	400	10
	Total dissolved solids	297	386	476	539	1,030	10
	Ammonia (as N)	0.08	--	--	--	--	1
	Nitrate plus nitrite (as N)	0.08	--	--	--	--	1
	Nitrate (as N)	--	0.63	4.9	10.4	41.0	8
	Nitrite (as N)	<0.01	--	--	--	--	1
	Orthophosphate (as P)	0.03	--	--	--	--	1
	Boron	50.0	--	--	--	--	1
	Iron	<3.0	--	--	--	120	2
	Iron, unfiltered	10.0	10.0	10.0	25.0	40.0	4
	Manganese	5.0	--	--	--	51.0	2
Quaternary landslide deposits	pH (standard units)	8.0	--	--	--	--	1
	Specific conductance (µS/cm)	328	--	--	--	--	1
	Hardness (as CaCO <sub>3</sub> )	162	--	--	--	--	1
	Calcium	45.0	--	--	--	--	1
	Magnesium	12.0	--	--	--	--	1
	Sodium	1.4	--	--	--	--	1
	Potassium	0.50	--	--	--	--	1
	Sodium adsorption ratio (unitless)	0.05	--	--	--	--	1
	Alkalinity (as CaCO <sub>3</sub> )	108	--	--	--	--	1
	Chloride	0.50	--	--	--	--	1
	Fluoride	0.10	--	--	--	--	1
	Silica	5.4	--	--	--	--	1
	Sulfate	60.0	--	--	--	--	1
	Total dissolved solids	187	--	--	--	--	1
Fowkes aquifer	pH (standard units)	7.3	7.4	7.8	7.9	8.2	7
	Specific conductance (µS/cm)	385	525	696	980	2,820	7
	Hardness (as CaCO <sub>3</sub> )	186	240	263	288	400	6
	Calcium	48.4	53.0	61.0	73.0	88.0	6
	Magnesium	14.7	24.0	25.5	30.2	43.2	6
	Sodium	17.0	18.7	68.0	135	490	6
	Potassium	1.6	3.5	5.1	6.6	20.7	5

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{CaCO}_3$ , calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Fowkes aquifer— Continued	Sodium adsorption ratio (unitless)	0.44	--	--	--	1.6	2
	Alkalinity (as $\text{CaCO}_3$ )	153	178	250	312	334	6
	Chloride	21.9	23.0	98.0	166	710	6
	Fluoride	0.06	0.27	0.40	0.40	0.45	5
	Silica	10.0	36.3	41.0	41.5	59.0	5
	Sulfate	13.0	46.5	51.5	52.0	190	6
	Total dissolved solids	248	350	537	640	1,570	6
	Nitrate (as N)	0.14	0.24	0.32	0.90	1.7	5
	Nitrite (as N)	<0.02	--	--	--	0.05	2
	Arsenic	--	--	--	--	4.0	3
	Barium	13.0	--	189	--	250	3
	Boron	20.0	--	60.0	--	155	3
	Cadmium	--	--	--	--	<1.0	3
	Chromium	<1.0	--	--	--	3.0	2
	Copper	--	--	--	--	<10.0	3
	Iron	--	11.0	41.3	96.0	125	4
	Iron, unfiltered	--	46.4	129	217	235	4
	Lead	--	--	--	--	<1.0	3
	Manganese	--	9.5	10.0	12.0	14.0	4
	Mercury	--	--	--	--	<0.20	3
	Nickel	--	--	--	--	<30.0	3
	Selenium	--	--	--	--	<1.0	3
	Silver	--	--	--	--	<1.0	3
	Zinc	15.0	--	20.0	--	35.0	3
	Gross alpha radioactivity (picocuries per liter)	5.3	--	--	--	--	1
	Gross beta radioactivity (picocuries per liter)	3.9	--	--	--	--	1
	Radium-226 (picocuries per liter)	<0.20	--	--	--	--	1
	Radium-228 (picocuries per liter)	<1.0	--	--	--	--	1
	Uranium	11.2	--	--	--	--	1
Angelo Member of the Green River Formation	pH (standard units)	7.4	--	--	--	--	1
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	400	--	--	--	--	1
	Hardness (as $\text{CaCO}_3$ )	210	--	--	--	--	1
	Calcium	46.0	--	--	--	--	1
	Magnesium	23.0	--	--	--	--	1
	Sodium	11.0	--	--	--	--	1
	Potassium	2.4	--	--	--	--	1
	Sodium adsorption ratio (unitless)	0.30	--	--	--	--	1
	Alkalinity (as $\text{CaCO}_3$ )	210	--	--	--	--	1

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming. —Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO<sub>3</sub>, calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisitic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Angelo Member of the Green River Formation—Continued	Chloride	5.0	--	--	--	--	1
	Fluoride	0.40	--	--	--	--	1
	Silica	14.0	--	--	--	--	1
	Sulfate	15.0	--	--	--	--	1
	Total dissolved solids	244	--	--	--	--	1
	Ammonia plus organic nitrogen (as N)	0.02	--	--	--	--	1
	Ammonia plus organic nitrogen, unfiltered (as N)	0.04	--	--	--	--	1
	Ammonia (as N)	<0.01	--	--	--	--	1
	Ammonia, unfiltered (as N)	<0.01	--	--	--	--	1
	Nitrate plus nitrite (as N)	0.82	--	--	--	--	1
	Organic nitrogen	0.02	--	--	--	--	1
	Organic nitrogen, unfiltered	0.04	--	--	--	--	1
	Total nitrogen	0.84	--	--	--	--	1
	Total nitrogen, unfiltered	0.86	--	--	--	--	1
	Orthophosphate (as P)	0.02	--	--	--	--	1
	Phosphorus	0.01	--	--	--	--	1
	Phosphorus, unfiltered	0.01	--	--	--	--	1
	Boron	50.0	--	--	--	--	1
	Iron	20.0	--	--	--	--	1
	Manganese	<10.0	--	--	--	--	1
Fossil Butte Member of the Green River Formation	pH (standard units)	7.4	7.4	7.5	7.7	7.7	7
	Specific conductance (µS/cm)	623	976	1,040	1,130	1,210	7
	Hardness (as CaCO <sub>3</sub> )	278	431	499	572	626	6
	Calcium	57.0	100	105	130	140	6
	Magnesium	33.0	44.0	56.0	63.0	67.0	6
	Sodium	9.7	18.0	32.5	45.0	53.0	6
	Potassium	0.40	1.3	1.9	2.4	2.8	6
	Sodium adsorption ratio (unitless)	0.25	0.31	0.65	0.84	1.1	6
	Alkalinity (as CaCO <sub>3</sub> )	199	233	279	304	340	6
	Chloride	6.8	11.0	14.5	20.0	24.0	6
	Fluoride	0.20	0.30	0.30	0.30	0.50	6
	Silica	11.0	12.0	16.0	21.0	28.0	6
	Sulfate	87.0	260	280	400	400	6
	Total dissolved solids	333	704	751	826	908	6
	Iron	--	--	--	--	<3.0	5
	Manganese	--	--	--	--	2.0	5
Wasatch aquifer	pH (standard units)	7.1	7.5	7.7	8.0	8.6	22
	Specific conductance (µS/cm)	360	568	765	994	8,500	23
	Hardness (as CaCO <sub>3</sub> )	10.0	240	322	360	900	21

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO<sub>3</sub>, calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Wasatch aquifer— Continued	Calcium	3.1	49.0	58.0	80.0	200	21
	Magnesium	0.60	25.0	38.0	51.0	97.0	21
	Sodium	4.7	22.0	28.0	79.0	2,000	21
	Potassium	1.2	2.6	4.3	5.4	14.0	19
	Sodium adsorption ratio (unitless)	0.11	0.56	0.75	1.9	63.0	12
	Alkalinity (as CaCO <sub>3</sub> )	180	217	273	301	384	21
	Chloride	8.7	18.0	31.0	59.0	2,700	21
	Fluoride	0.20	0.30	0.40	0.67	1.9	18
	Silica	3.7	6.5	8.8	13.0	45.4	18
	Sulfate	4.1	22.0	44.0	100	790	21
	Total dissolved solids	176	313	411	543	5,400	20
	Ammonia (as N)	0.07	0.14	0.70	1.4	1.6	4
	Ammonia, unfiltered (as N)	1.8	--	--	--	--	1
	Nitrate plus nitrite (as N)	--	0.04	0.09	0.34	1.1	6
	Nitrate (as N)	--	0.16	0.29	0.59	2.7	13
	Nitrite (as N)	--	--	--	--	0.19	5
	Orthophosphate (as P)	0.01	--	--	--	--	1
	Aluminum	--	--	--	--	<4,500	3
	Antimony	<3.0	--	--	--	--	1
	Arsenic	--	--	--	--	16.0	7
	Barium	--	58.0	103	200	420	7
	Beryllium	--	--	--	--	<6.0	2
	Boron	--	49.0	105	140	460	14
	Cadmium	--	--	--	--	<10.0	6
	Chromium	--	--	--	--	<50.0	5
	Cobalt	<10.0	--	--	--	--	1
	Copper	--	--	--	--	20.0	5
	Cyanide	--	--	--	--	<0.01	2
	Iron	--	6.2	130	690	1,600	13
	Iron, unfiltered	--	32.9	150	420	7,800	10
	Lead	--	--	--	--	<50.0	7
	Lithium	60.0	--	--	--	--	1
	Manganese	--	0.82	3.3	20.0	200	9
	Manganese, unfiltered	<10.0	--	--	--	220	2
	Mercury	--	--	--	--	<1.0	7
	Nickel	--	--	--	--	60.0	5
	Selenium	--	--	--	--	<10.0	7
	Silver	--	--	--	--	<20.0	6
	Thallium	<1.0	--	--	--	--	1

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{CaCO}_3$ , calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisitic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Wasatch aquifer— Continued	Vanadium	<10.0	--	--	--	--	1
	Zinc	20.0	22.0	30.0	180	1,100	5
	Gross alpha radioactivity (picocuries per liter)	1.8	--	--	--	9.0	2
	Gross beta radioactivity (picocuries per liter)	<2.0	--	--	--	19.0	2
	Radium-226 (picocuries per liter)	0.90	--	--	--	2.9	2
	Radium-228 (picocuries per liter)	<1.0	--	--	--	--	1
	Radon-222, unfiltered (picocuries per liter)	380	--	--	--	--	1
	Uranium	--	--	--	--	<300	3
Evanston aquifer	pH (standard units)	7.4	--	--	--	8.3	2
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	985	--	--	--	7,590	2
	Hardness (as $\text{CaCO}_3$ )	194	--	--	--	413	2
	Calcium	30.0	--	--	--	88.0	2
	Magnesium	29.0	--	--	--	47.0	2
	Sodium	48.0	--	--	--	1,800	2
	Potassium	3.1	--	--	--	23.0	2
	Sodium adsorption ratio (unitless)	1.0	--	--	--	56.2	2
	Alkalinity (as $\text{CaCO}_3$ )	277	--	--	--	525	2
	Chloride	30.0	--	--	--	1,600	2
	Fluoride	0.50	--	--	--	2.2	2
	Silica	4.7	--	--	--	12.0	2
	Sulfate	230	--	--	--	1,100	2
	Total dissolved solids	662	--	--	--	4,880	2
	Ammonia (as N)	1.1	--	--	--	--	1
	Nitrate plus nitrite (as N)	<0.05	--	--	--	--	1
	Nitrate (as N)	<0.05	--	--	--	--	1
	Nitrite (as N)	<0.01	--	--	--	--	1
	Orthophosphate (as P)	0.02	--	--	--	--	1
	Iron	<3.0	--	--	--	510	2
	Manganese	<1.0	--	--	--	70.0	2
Frontier aquifer	pH (standard units)	8.1	--	--	--	--	1
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	910	--	--	--	--	1
	Hardness (as $\text{CaCO}_3$ )	384	--	--	--	--	1
	Calcium	50.0	--	--	--	--	1
	Magnesium	63.0	--	--	--	--	1
	Sodium	102	--	--	--	--	1
	Potassium	14.0	--	--	--	--	1
	Alkalinity (as $\text{CaCO}_3$ )	334	--	--	--	--	1
	Chloride	23.0	--	--	--	--	1

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO<sub>3</sub>, calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Frontier aquifer— Continued	Fluoride	0.74	--	--	--	--	1
	Sulfate	256	--	--	--	--	1
	Total dissolved solids	608	--	--	--	--	1
	Nitrate (as N)	0.22	--	--	--	--	1
	Arsenic	<10.0	--	--	--	--	1
	Barium	<50.0	--	--	--	--	1
	Cadmium	<10.0	--	--	--	--	1
	Chromium	<50.0	--	--	--	--	1
	Lead	<50.0	--	--	--	--	1
	Mercury	<1.0	--	--	--	--	1
	Selenium	<10.0	--	--	--	--	1
	Silver	<20.0	--	--	--	--	1
	Gross alpha radioactivity (picocuries per liter)	23.0	--	--	--	--	1
	Gross beta radioactivity (picocuries per liter)	20.0	--	--	--	--	1
	Radium-226 (picocuries per liter)	0.60	--	--	--	--	1
	Uranium	20.0	--	--	--	--	1
Sage Junction Formation	pH (standard units)	7.7	--	--	--	--	1
	Specific conductance (µS/cm)	857	--	--	--	--	1
	Hardness (as CaCO <sub>3</sub> )	386	--	--	--	--	1
	Calcium	100	--	--	--	--	1
	Magnesium	33.0	--	--	--	--	1
	Sodium	27.0	--	--	--	--	1
	Potassium	2.0	--	--	--	--	1
	Sodium adsorption ratio (unitless)	0.60	--	--	--	--	1
	Alkalinity (as CaCO <sub>3</sub> )	285	--	--	--	--	1
	Chloride	65.0	--	--	--	--	1
	Fluoride	0.20	--	--	--	--	1
	Silica	7.7	--	--	--	--	1
	Sulfate	38.0	--	--	--	--	1
	Total dissolved solids	458	--	--	--	--	1
	Iron	<3.0	--	--	--	--	1
	Manganese	<1.0	--	--	--	--	1
Bear River aquifer	pH (standard units)	7.7	--	--	--	--	1
	Specific conductance (µS/cm)	615	--	--	--	--	1
	Hardness (as CaCO <sub>3</sub> )	320	--	--	--	--	1
	Calcium	89.0	--	--	--	--	1
	Magnesium	25.0	--	--	--	--	1
	Sodium	11.0	--	--	--	--	1
	Potassium	1.1	--	--	--	--	1

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

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Hydrogeologic unit	Characterisite or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Bear River aquifer— Continued	Sodium adsorption ratio (unitless)	0.30	--	--	--	--	1
	Alkalinity (as $\text{CaCO}_3$ )	199	--	--	--	--	1
	Chloride	3.9	--	--	--	--	1
	Fluoride	0.20	--	--	--	--	1
	Silica	13.0	--	--	--	--	1
	Sulfate	120	--	--	--	--	1
	Total dissolved solids	386	--	--	--	--	1
	Nitrate plus nitrite (as N)	0.70	--	--	--	--	1
	Boron	60.0	--	--	--	--	1
	Iron, unfiltered	30.0	--	--	--	--	1
Thomas Fork aquifer	pH (standard units)	7.7	--	--	--	--	1
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	560	--	--	--	670	2
	Hardness (as $\text{CaCO}_3$ )	293	--	--	--	--	1
	Calcium	83.0	--	--	--	--	1
	Magnesium	21.0	--	--	--	--	1
	Sodium	6.5	--	--	--	--	1
	Potassium	0.90	--	--	--	--	1
	Sodium adsorption ratio (unitless)	0.17	--	--	--	--	1
	Alkalinity (as $\text{CaCO}_3$ )	170	--	--	--	--	1
	Chloride	4.9	--	--	--	--	1
	Fluoride	0.19	--	--	--	--	1
	Silica	6.6	--	--	--	--	1
	Sulfate	129	--	--	--	--	1
	Total dissolved solids	390	--	--	--	--	1
	Nitrate plus nitrite (as N)	0.68	--	--	--	--	1
	Arsenic	<5.0	--	--	--	--	1
	Barium	<200	--	--	--	--	1
	Boron	<100	--	--	--	--	1
	Cadmium	<2.0	--	--	--	--	1
	Chromium	<10.0	--	--	--	--	1
	Copper	<20.0	--	--	--	--	1
	Iron	<50.0	--	--	--	--	1
	Lead	<5.0	--	--	--	--	1
	Manganese	<20.0	--	--	--	--	1
	Mercury	<1.0	--	--	--	--	1
	Selenium	<5.0	--	--	--	--	1
	Silver	<10.0	--	--	--	--	1
	Zinc	<20.0	--	--	--	--	1
	Gross alpha radioactivity (picocuries per liter)	<1.0	--	--	--	--	1

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; CaCO<sub>3</sub>, calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisitic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Thomas Fork aquifer—Continued	Gross beta radioactivity (picocuries per liter)	<1.0	--	--	--	--	1
	Radium-226 (picocuries per liter)	<0.20	--	--	--	--	1
	Radium-228 (picocuries per liter)	<1.0	--	--	--	--	1
	Uranium	<0.30	--	--	--	--	1
Gannett aquifer and confining unit	pH (standard units)	7.5	7.5	7.6	7.7	8.5	7
	Specific conductance (µS/cm)	430	479	526	780	1,460	8
	Hardness (as CaCO <sub>3</sub> )	57.0	120	250	300	310	6
	Calcium	7.8	23.0	66.0	85.0	86.0	6
	Magnesium	9.1	14.0	19.0	23.0	25.0	6
	Sodium	6.8	7.1	10.4	65.0	280	6
	Potassium	0.70	1.1	1.1	1.7	4.3	6
	Sodium adsorption ratio (unitless)	0.40	--	2.6	--	16.1	3
	Alkalinity (as CaCO <sub>3</sub> )	170	170	190	211	326	6
	Chloride	5.9	6.5	7.0	37.0	140	6
	Fluoride	0.20	0.21	0.30	0.80	2.3	6
	Silica	7.5	--	8.5	--	9.7	3
	Sulfate	7.0	25.0	129	134	180	6
	Total dissolved solids	243	291	376	388	854	6
	Nitrate plus nitrite (as N)	0.11	--	--	--	2.1	2
	Nitrate (as N)	0.02	--	--	--	--	1
	Arsenic	1.3	--	1.9	--	2.5	3
	Barium	--	--	--	--	<1,000	3
	Boron	30.0	--	--	--	50.0	2
	Cadmium	--	--	--	--	<10.0	3
	Chromium	--	--	--	--	<50.0	3
	Copper	--	--	--	--	<50.0	3
	Iron	--	--	--	--	270	5
	Iron, unfiltered	20.0	--	--	--	--	1
	Lead	--	--	--	--	<0.50	3
	Manganese	--	--	--	--	<50.0	4
	Mercury	--	--	--	--	<0.50	3
	Selenium	--	--	--	--	<0.50	3
	Silver	--	--	--	--	<50.0	3
	Zinc	--	--	--	--	<20.0	3
Preuss Sandstone or Redbeds	pH (standard units)	7.6	--	--	--	7.7	2
	Specific conductance (µS/cm)	1,260	--	--	--	1,350	2
	Hardness (as CaCO <sub>3</sub> )	220	--	--	--	310	2
	Calcium	70.0	--	--	--	88.0	2
	Magnesium	12.0	--	--	--	21.0	2

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{CaCO}_3$ , calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Preuss Sandstone or Redbeds—Continued	Sodium	150	--	--	--	170	2
	Potassium	1.2	--	--	--	2.3	2
	Sodium adsorption ratio (unitless)	3.7	--	--	--	4.9	2
	Alkalinity (as $\text{CaCO}_3$ )	200	--	--	--	226	2
	Chloride	200	--	--	--	210	2
	Fluoride	0.10	--	--	--	0.20	2
	Silica	12.0	--	--	--	12.0	2
	Sulfate	67.0	--	--	--	99.0	2
	Total dissolved solids	664	--	--	--	715	2
	Nitrate plus nitrite (as N)	0.35	--	--	--	1.6	2
	Boron	40.0	--	--	--	40.0	2
	Iron, unfiltered	20.0	--	--	--	50.0	2
Twin Creek aquifer	pH (standard units)	7.4	--	--	--	7.6	2
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	463	--	--	--	592	2
	Hardness (as $\text{CaCO}_3$ )	208	--	--	--	293	2
	Calcium	65.0	--	--	--	76.0	2
	Magnesium	11.0	--	--	--	25.0	2
	Sodium	11.0	--	--	--	12.0	2
	Potassium	0.90	--	--	--	2.3	2
	Sodium adsorption ratio (unitless)	0.28	--	--	--	0.36	2
	Alkalinity (as $\text{CaCO}_3$ )	150	--	--	--	223	2
	Chloride	7.7	--	--	--	11.0	2
	Fluoride	0.10	--	--	--	0.50	2
	Silica	14.0	--	--	--	15.0	2
	Sulfate	75.0	--	--	--	86.0	2
	Total dissolved solids	282	--	--	--	366	2
	Iron	36.0	--	--	--	800	2
	Manganese	<1.0	--	--	--	190	2
Nugget aquifer	pH (standard units)	6.2	7.4	7.7	8.1	8.1	6
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	64.0	229	441	596	1,270	6
	Hardness (as $\text{CaCO}_3$ )	24.6	100	202	288	357	5
	Calcium	7.7	31.0	61.0	71.0	77.0	5
	Magnesium	1.3	5.8	12.0	27.0	40.0	5
	Sodium	2.3	6.8	7.2	8.0	148	5
	Potassium	0.50	0.65	1.1	1.5	1.6	4
	Sodium adsorption ratio (unitless)	0.17	0.20	0.22	0.30	3.4	5
	Alkalinity (as $\text{CaCO}_3$ )	21.0	98.0	153	210	300	5
	Chloride	1.9	3.8	9.1	11.0	50.0	5
	Fluoride	0.10	0.15	0.20	0.20	0.20	4
	Silica	9.1	11.1	13.5	15.5	17.0	4

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{CaCO}_3$ , calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisitic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Nugget aquifer— Continued	Sulfate	4.1	9.1	13.0	110	328	5
	Total dissolved solids	54.0	143	210	384	824	5
	Nitrate (as N)	0.05	--	--	--	1.1	2
	Phosphorus, unfiltered	0.01	--	--	--	--	1
	Iron	<3.0	--	--	--	26.0	2
	Manganese	--	--	--	--	<1.0	2
Thaynes aquifer	pH (standard units)	7.4	7.4	7.7	7.9	7.9	4
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	241	318	484	602	631	4
	Hardness (as $\text{CaCO}_3$ )	123	166	256	307	310	4
	Calcium	35.0	46.0	63.0	72.0	75.0	4
	Magnesium	8.6	12.3	22.0	30.5	33.0	4
	Sodium	1.0	2.2	7.7	15.0	18.0	4
	Potassium	0.20	0.40	1.4	2.6	3.1	4
	Sodium adsorption ratio (unitless)	0.04	0.07	0.20	0.35	0.40	4
	Alkalinity (as $\text{CaCO}_3$ )	120	161	205	224	240	4
	Chloride	0.30	0.95	4.7	8.0	8.3	4
	Fluoride	0.10	0.10	0.20	0.35	0.40	4
	Silica	4.7	7.1	9.5	11.8	14.0	4
	Sulfate	6.2	7.8	52.2	96.0	97.0	4
	Total dissolved solids	127	179	299	377	386	4
	Nitrate plus nitrite (as N)	0.02	--	--	--	--	1
	Boron	80.0	--	--	--	--	1
	Iron	<3.0	--	--	--	--	1
	Iron, unfiltered	700	--	--	--	--	1
	Manganese	<1.0	--	--	--	--	1
Woodside confining unit	pH (standard units)	7.7	--	--	--	7.8	2
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	430	--	--	--	518	2
	Hardness (as $\text{CaCO}_3$ )	250	--	--	--	--	1
	Calcium	54.0	--	--	--	--	1
	Magnesium	28.0	--	--	--	--	1
	Sodium	5.7	--	--	--	--	1
	Potassium	1.0	--	--	--	--	1
	Sodium adsorption ratio (unitless)	0.16	--	--	--	--	1
	Alkalinity (as $\text{CaCO}_3$ )	222	--	--	--	--	1
	Chloride	3.6	--	--	--	--	1
	Fluoride	0.30	--	--	--	--	1
	Silica	11.0	--	--	--	--	1
	Sulfate	56.0	--	--	--	--	1
	Total dissolved solids	302	--	--	--	--	1
	Iron	<3.0	--	--	--	--	1

**Appendix E.** Summary statistics for environmental water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; <, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter;  $\mu\text{S}/\text{cm}$ , microsiemens per centimeter at 25 degrees Celsius;  $\text{CaCO}_3$ , calcium carbonate; N, nitrogen; P, phosphorus]

Hydrogeologic unit	Characterisic or constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Woodside confining unit—Continued	Manganese	<1.0	--	--	--	--	1
Phosphoria aquifer	pH (standard units)	7.5	--	--	--	7.8	2
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	1,650	--	--	--	4,830	2
	Hardness (as $\text{CaCO}_3$ )	840	--	--	--	2,390	2
	Calcium	230	--	--	--	526	2
	Magnesium	65.0	--	--	--	262	2
	Sodium	70.0	--	--	--	424	2
	Potassium	7.9	--	--	--	51.0	2
	Sodium adsorption ratio (unitless)	1.1	--	--	--	3.8	2
	Alkalinity (as $\text{CaCO}_3$ )	146	--	--	--	238	2
	Chloride	51.0	--	--	--	356	2
	Fluoride	0.80	--	--	--	2.6	2
	Silica	8.3	--	--	--	9.2	2
	Sulfate	650	--	--	--	2,620	2
	Total dissolved solids	1,230	--	--	--	4,560	2
	Nitrate plus nitrite (as N)	0.13	--	--	--	--	1
	Boron	<1.0	--	--	--	230	2
	Iron, unfiltered	20.0	--	--	--	--	1
Wells aquifer	pH (standard units)	7.4	--	--	--	8.1	2
	Specific conductance ( $\mu\text{S}/\text{cm}$ )	193	--	--	--	839	2
	Hardness (as $\text{CaCO}_3$ )	100	--	--	--	330	2
	Calcium	29.0	--	--	--	75.0	2
	Magnesium	6.8	--	--	--	34.0	2
	Sodium	0.50	--	--	--	50.0	2
	Potassium	0.20	--	--	--	3.1	2
	Sodium adsorption ratio (unitless)	0.02	--	--	--	1.2	2
	Alkalinity (as $\text{CaCO}_3$ )	225	--	--	--	--	1
	Chloride	3.1	--	--	--	48.0	2
	Fluoride	0.30	--	--	--	0.50	2
	Silica	5.3	--	--	--	12.0	2
	Sulfate	12.0	--	--	--	160	2
	Total dissolved solids	110	--	--	--	521	2
	Nitrate plus nitrite (as N)	0.83	--	--	--	--	1
	Boron	80.0	--	--	--	--	1
	Iron, unfiltered	40.0	--	--	--	--	1



# Appendix F

*Produced Water Samples*

**Appendix F.** Summary statistics for produced-water samples, Bear River Basin, Wyoming.

[--, not applicable; &lt;, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter]

Hydrogeologic unit	Constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Evanston aquifer	pH (standard units)	7.1	--	--	--	--	1
	Calcium	342	--	--	--	--	1
	Magnesium	42.0	--	--	--	--	1
	Sodium	1,280	--	--	--	--	1
	Potassium	17.0	--	--	--	--	1
	Bicarbonate	579	--	--	--	--	1
	Chloride	2,300	--	--	--	--	1
	Sulfate	129	--	--	--	--	1
	Total dissolved solids	4,400	--	--	--	--	1
Frontier aquifer	pH (standard units)	8.2	--	--	--	--	1
	Calcium	305	--	--	--	--	1
	Magnesium	77.0	--	--	--	--	1
	Sodium	3,880	--	--	--	--	1
	Potassium	112	--	--	--	--	1
	Bicarbonate	1,170	--	--	--	--	1
	Chloride	4,900	--	--	--	--	1
	Sulfate	1,700	--	--	--	--	1
	Total dissolved solids	11,600	--	--	--	--	1
Aspen confining unit	pH (standard units)	8.1	--	--	--	8.4	2
	Calcium	1,060	--	--	--	1,100	2
	Magnesium	206	--	--	--	299	2
	Sodium	9,600	--	--	--	10,800	2
	Bicarbonate	1,800	--	--	--	1,820	2
	Chloride	16,500	--	--	--	18,000	2
	Sulfate	9.0	--	--	--	--	1
	Total dissolved solids	28,300	--	--	--	31,000	2
Bear River aquifer	Calcium	19.0	--	--	--	--	1
	Magnesium	30.0	--	--	--	--	1
	Sodium	431	--	--	--	--	1
	Bicarbonate	1,270	--	--	--	--	1
	Chloride	47.0	--	--	--	--	1
	Total dissolved solids	1,150	--	--	--	--	1
Twin Creek aquifer	pH (standard units)	4.8	5.7	7.4	7.7	8.2	7
	Calcium	913	1,120	5,890	10,900	28,700	7
	Magnesium	139	240	706	1,700	1,720	6
	Sodium	9,790	10,300	39,900	56,500	126,000	7
	Potassium	298	301	574	2,900	4,450	7
	Bicarbonate	134	146	281	415	1,310	7
	Carbonate	12.0	--	--	--	--	1
	Chloride	15,500	15,800	83,000	145,000	183,000	7

**Appendix F.** Summary statistics for produced-water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; &lt;, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter]

Hydrogeologic unit	Constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Twin Creek aquifer—Continued	Sulfate	550	640	1,650	4,000	18,000	7
	Total dissolved solids	31,100	31,400	137,000	235,000	329,000	7
Nugget aquifer	pH (standard units)	3.3	6.3	6.9	7.4	8.3	14
	Calcium	406	616	735	1,170	6,560	14
	Magnesium	18.0	62.0	117	157	977	14
	Sodium	4,200	6,240	10,300	16,000	35,600	14
	Potassium	31.0	146	524	700	4,520	9
	Bicarbonate	44.0	168	256	305	366	13
	Chloride	2,600	8,400	17,700	28,900	68,500	14
	Sulfate	428	1,800	2,650	3,900	6,400	14
	Total dissolved solids	14,100	18,900	33,500	45,000	113,000	14
	Iron	48,000	--	72,000	--	740,000	3
Thaynes aquifer	pH (standard units)	6.9	--	7.4	--	7.9	3
	Calcium	656	--	960	--	1,460	3
	Magnesium	122	--	195	--	214	3
	Sodium	12,700	--	15,800	--	28,700	3
	Potassium	686	--	--	--	--	1
	Bicarbonate	122	--	205	--	273	3
	Chloride	18,400	--	24,600	--	40,800	3
	Sulfate	1,130	--	3,800	--	4,150	3
	Total dissolved solids	36,600	--	46,100	--	72,600	3
Woodside confining unit	pH (standard units)	8.1	--	--	--	--	1
	Calcium	1,110	--	--	--	--	1
	Magnesium	184	--	--	--	--	1
	Sodium	8,550	--	--	--	--	1
	Potassium	535	--	--	--	--	1
	Bicarbonate	305	--	--	--	--	1
	Chloride	16,100	--	--	--	--	1
	Sulfate	765	--	--	--	--	1
	Total dissolved solids	25,000	--	--	--	--	1
Wells aquifer	pH (standard units)	7.1	--	--	--	--	1
	Calcium	9,900	--	--	--	--	1
	Magnesium	2,700	--	--	--	--	1
	Sodium	40,900	--	--	--	--	1
	Potassium	548	--	--	--	--	1
	Bicarbonate	2,680	--	--	--	--	1
	Chloride	86,000	--	--	--	--	1
	Sulfate	1,800	--	--	--	--	1
	Total dissolved solids	144,000	--	--	--	--	1

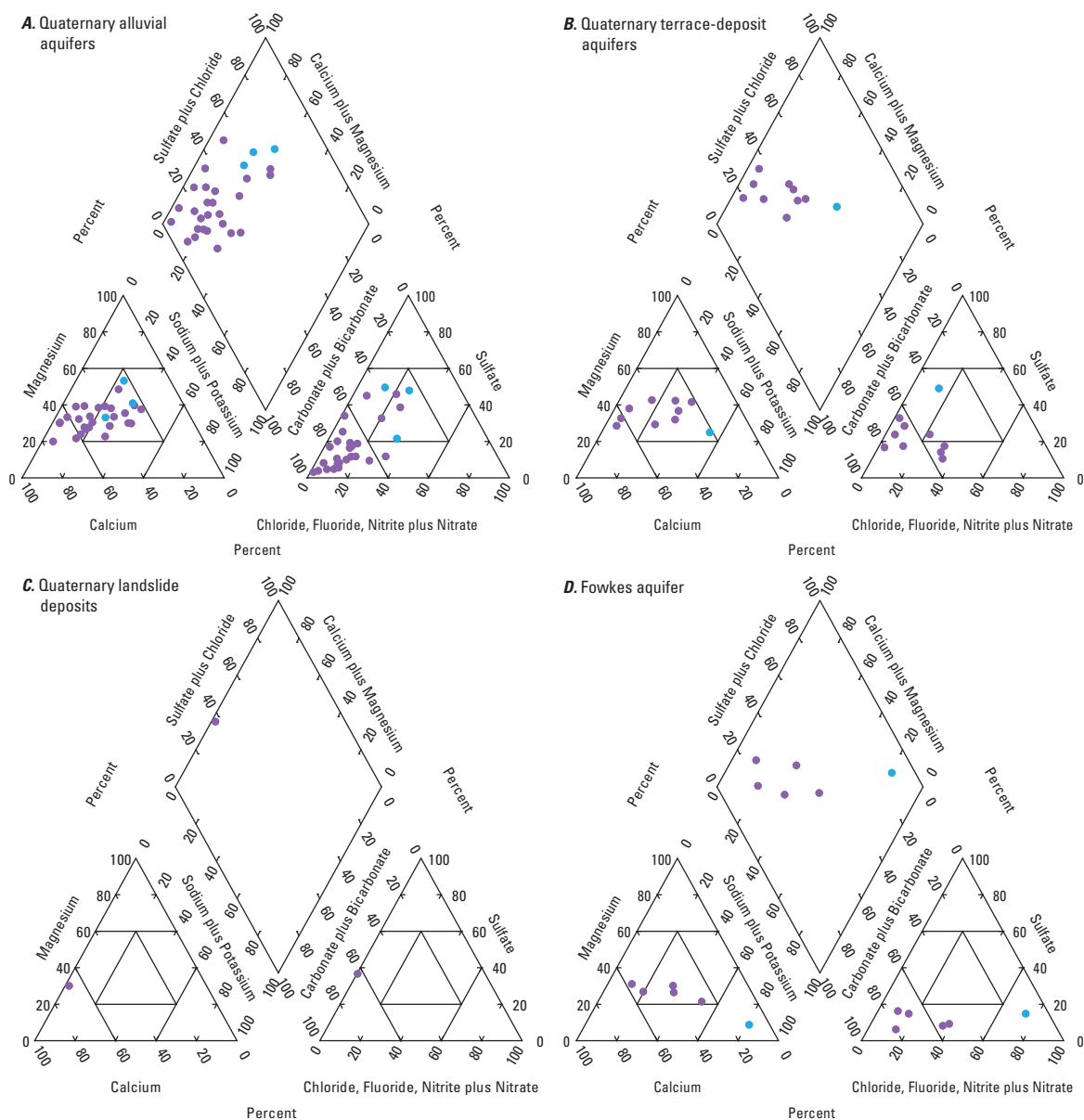
**Appendix F.** Summary statistics for produced-water samples, Bear River Basin, Wyoming.—Continued

[--, not applicable; &lt;, less than; Values in black are in milligrams per liter unless otherwise noted; values in blue are in micrograms per liter]

Hydrogeologic unit	Constituent	Minimum	25th percentile	Median	75th percentile	Maximum	Sample size
Madison aquifer	pH (standard units)	6.1	6.6	7.4	8.3	8.8	8
	Calcium	50.0	318	1,400	4,190	10,700	8
	Magnesium	15.0	37.0	262	635	4,170	8
	Sodium	29.0	2,800	7,400	14,300	44,100	8
	Potassium	8.0	174	600	1,150	1,960	8
	Bicarbonate	39.0	146	482	1,510	5,190	8
	Carbonate	12.0	--	--	--	154	2
	Chloride	82.0	4,000	16,000	26,400	98,000	8
	Sulfate	56.0	124	655	2,190	3,600	8
	Total dissolved solids	327	9,560	29,700	47,400	160,000	8
Bighorn aquifer	pH (standard units)	7.1	--	--	--	8.9	2
	Calcium	632	--	--	--	865	2
	Magnesium	180	--	--	--	306	2
	Sodium	4,430	--	--	--	4,710	2
	Potassium	565	--	--	--	2,270	2
	Bicarbonate	159	--	--	--	1,140	2
	Carbonate	72.0	--	--	--	--	1
	Chloride	8,150	--	--	--	11,100	2
	Sulfate	65.0	--	--	--	--	1
	Total dissolved solids	14,500	--	--	--	19,000	2

# Appendix G

*Major-Ion Composition  
and TDS-Concentration for  
Environmental Groundwater  
Samples*



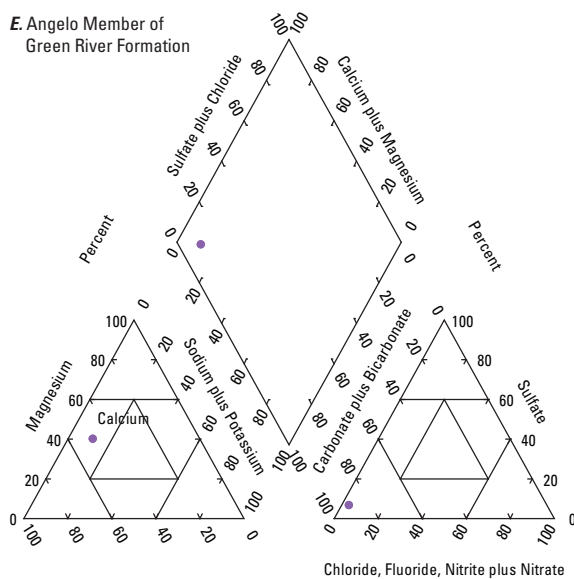
#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and U.S. Geological Survey salinity classification (Heath, 1983)

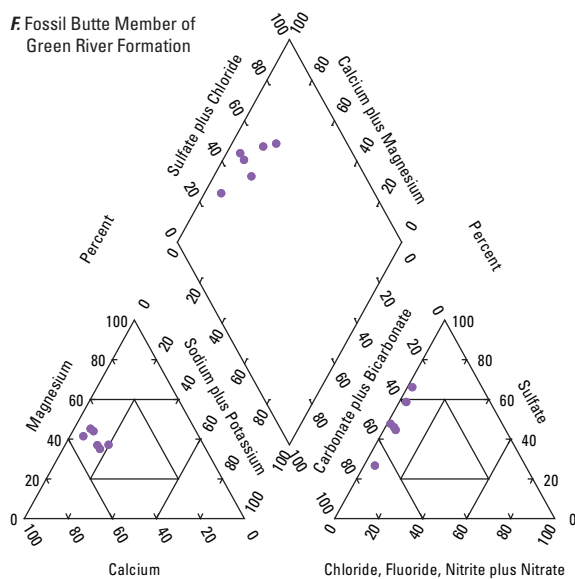
- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix G.** Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for environmental groundwater samples, Bear River Basin.

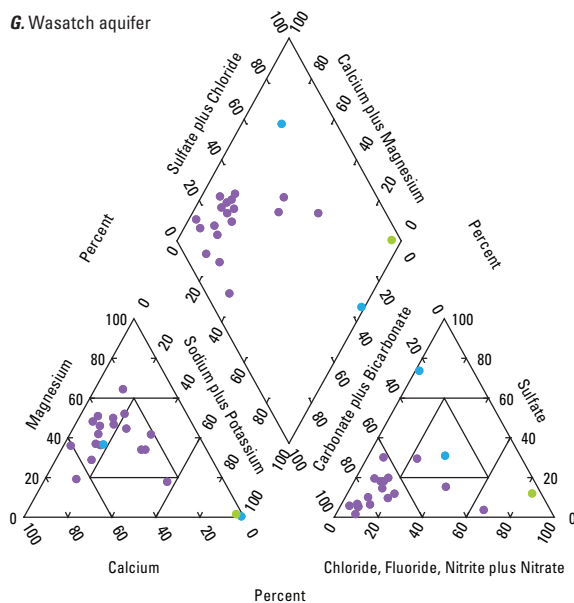
**E. Angelo Member of  
Green River Formation**



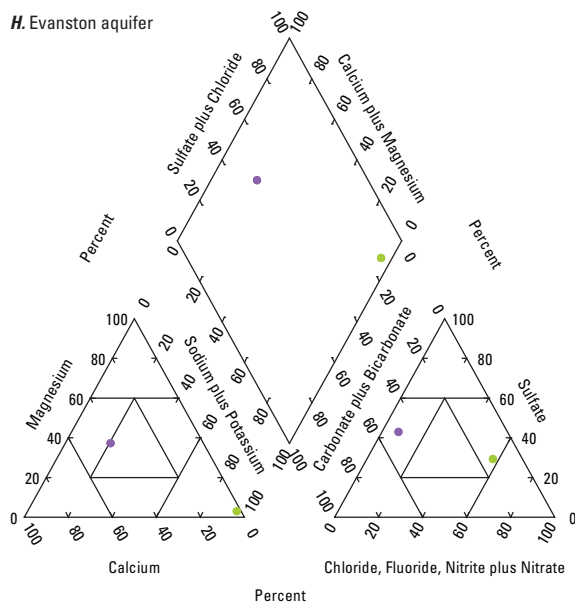
**F. Fossil Butte Member of  
Green River Formation**



**G. Wasatch aquifer**



**H. Evanston aquifer**



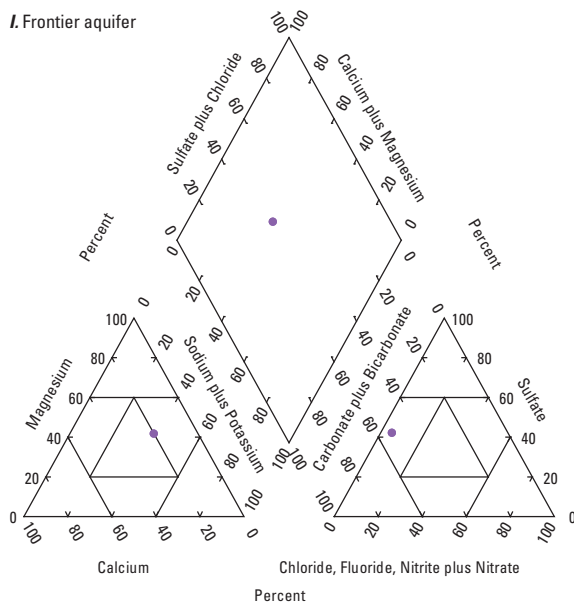
#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and  
U.S. Geological Survey salinity classification (Heath, 1983)

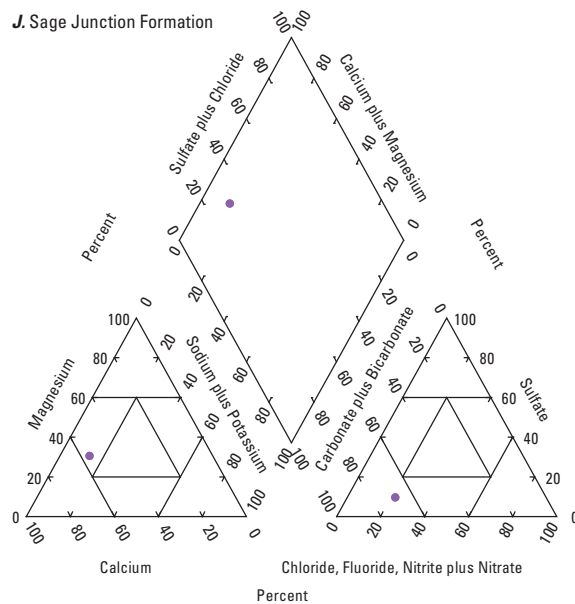
- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix G.** Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for environmental groundwater samples, Bear River Basin.—Continued

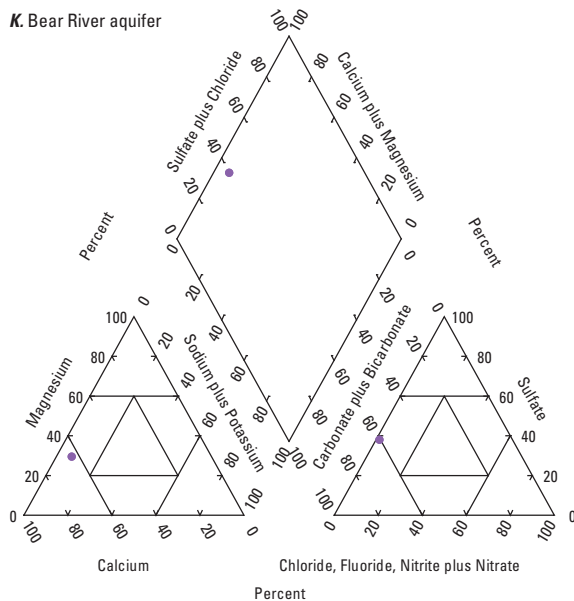
I. Frontier aquifer



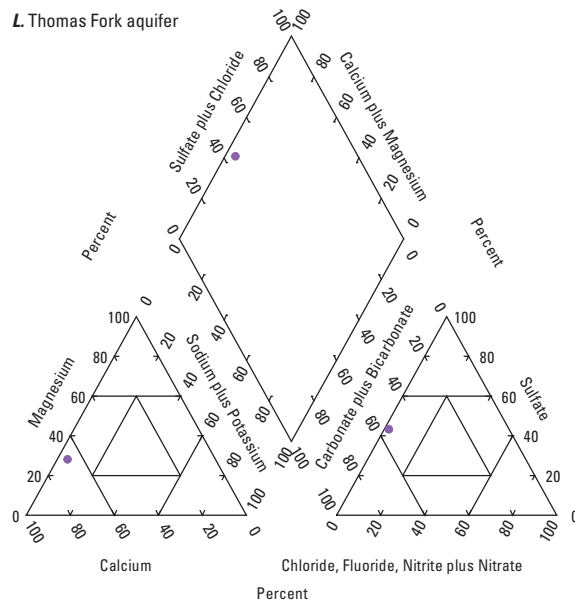
J. Sage Junction Formation



K. Bear River aquifer



L. Thomas Fork aquifer



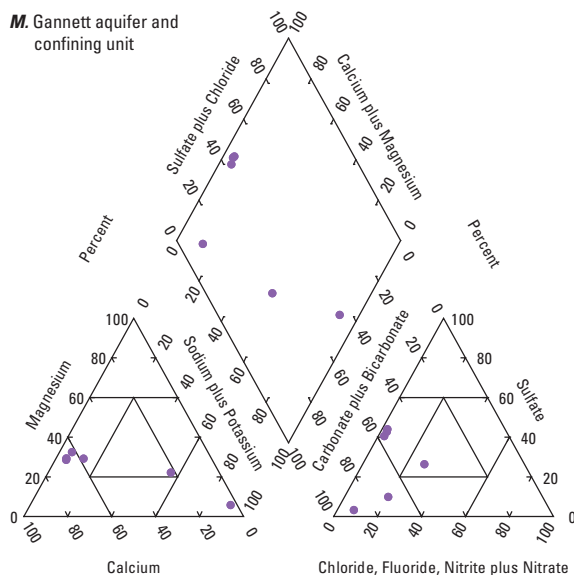
#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and  
U.S. Geological Survey salinity classification (Heath, 1983)

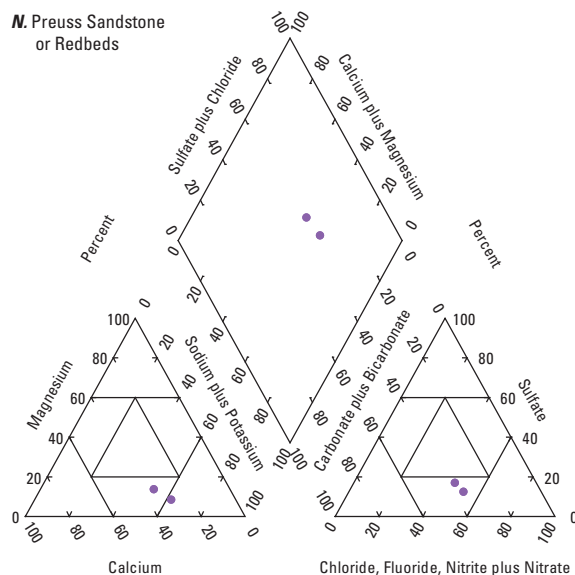
- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix G.** Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for environmental groundwater samples, Bear River Basin.—Continued

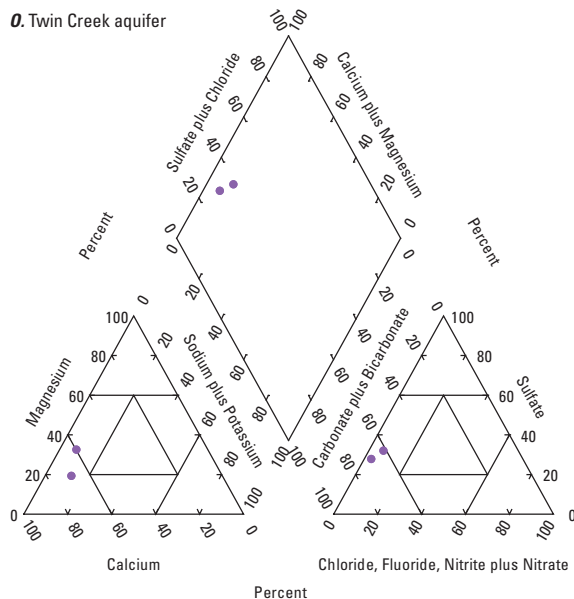
**M.** Gannett aquifer and confining unit



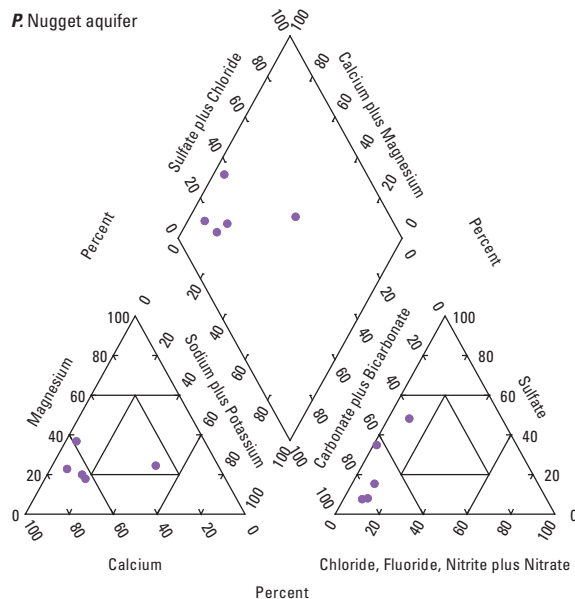
**N.** Preuss Sandstone or Redbeds



**O.** Twin Creek aquifer



**P.** Nugget aquifer



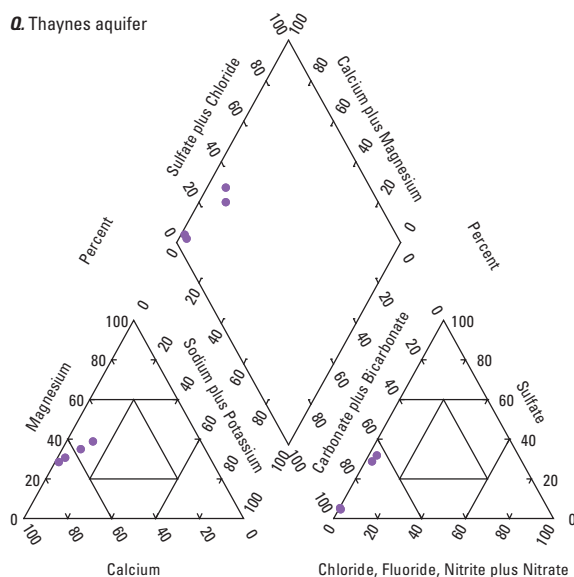
#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and U.S. Geological Survey salinity classification (Heath, 1983)

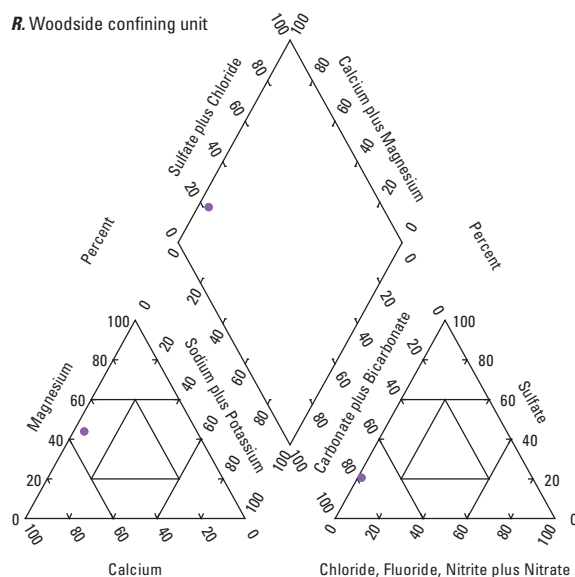
- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix G.** Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for environmental groundwater samples, Bear River Basin.—Continued

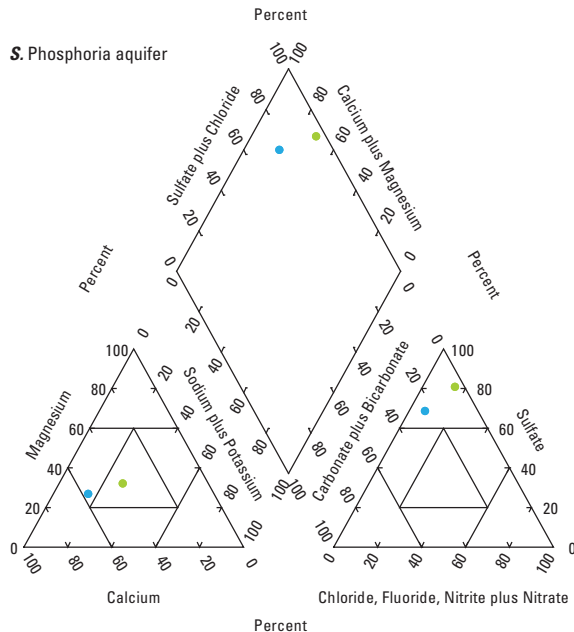
**Q. Thaynes aquifer**



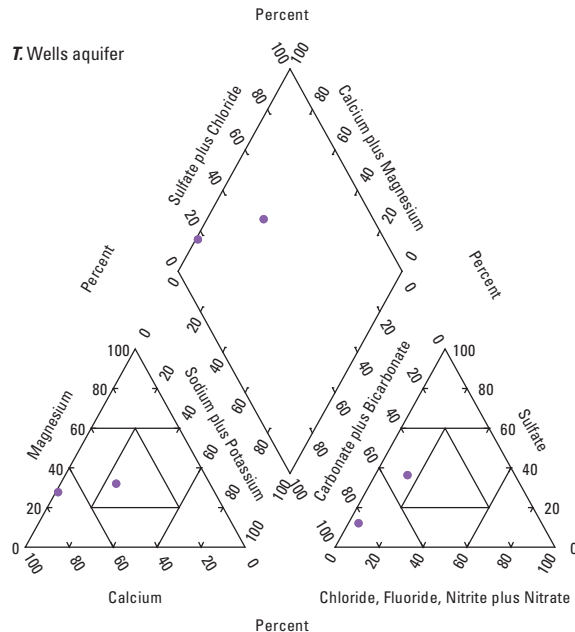
**R. Woodside confining unit**



**S. Phosphoria aquifer**



**T. Wells aquifer**



#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and  
U.S. Geological Survey salinity classification (Heath, 1983)

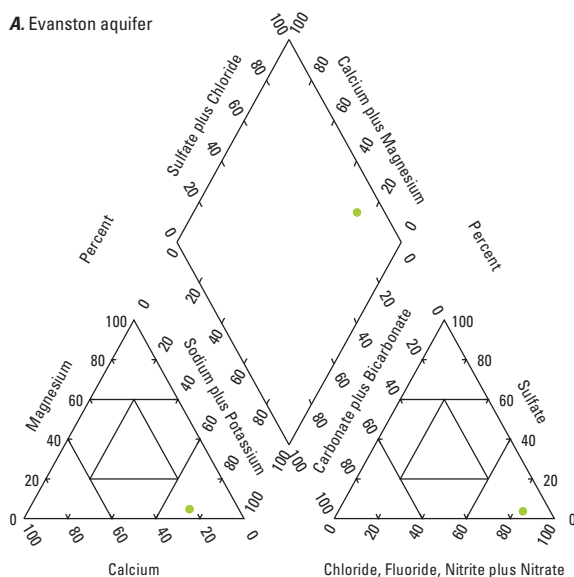
- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix G.** Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for environmental groundwater samples, Bear River Basin.—Continued

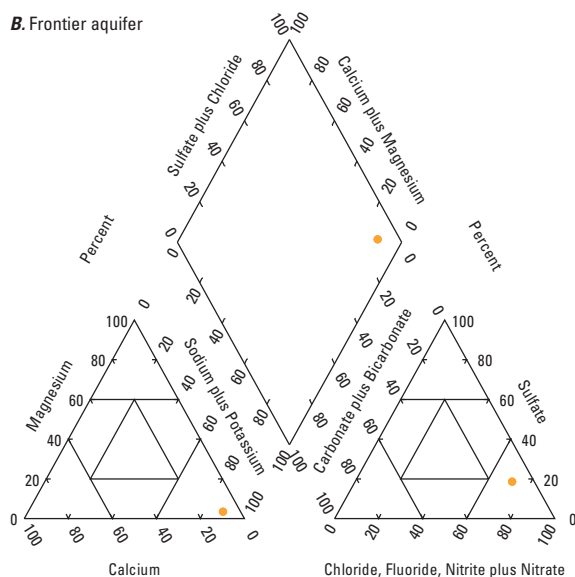
# Appendix H

*Major-Ion Composition  
and TDS-Concentration  
for Produced Groundwater  
Samples*

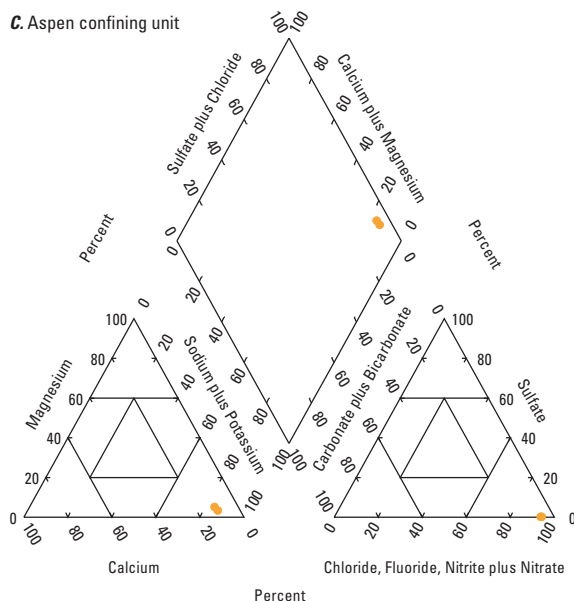
**A. Evanston aquifer**



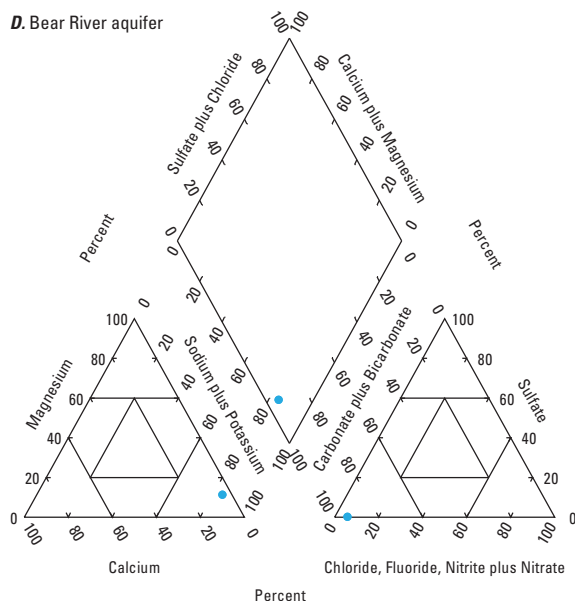
**B. Frontier aquifer**



**C. Aspen confining unit**



**D. Bear River aquifer**



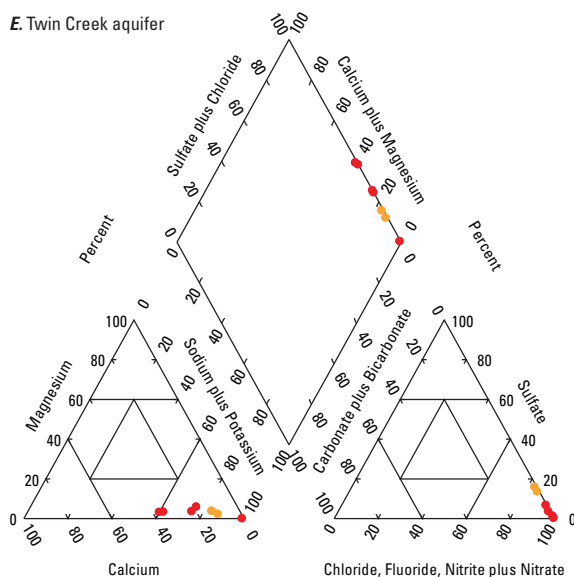
#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and  
U.S. Geological Survey salinity classification (Heath, 1983)

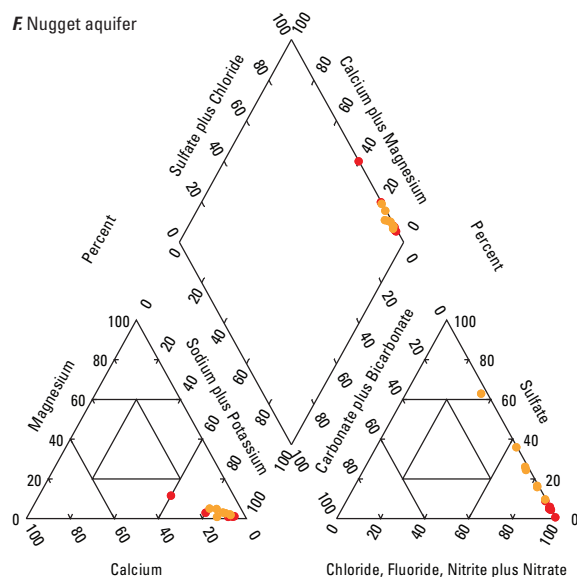
- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix H.** Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for produced groundwater samples, Bear River Basin.

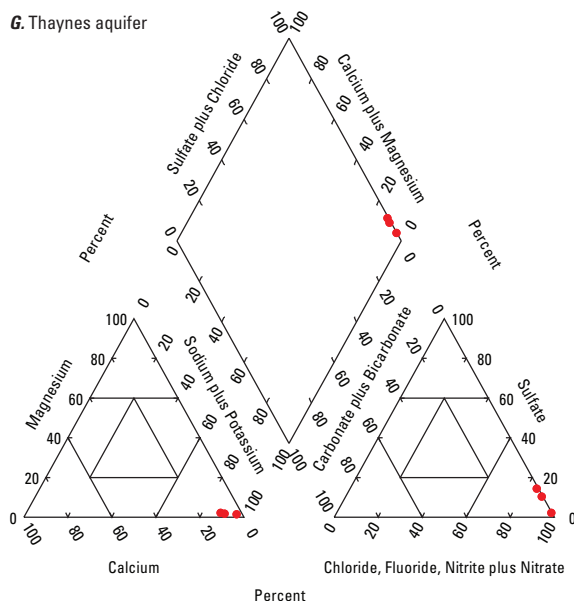
**E. Twin Creek aquifer**



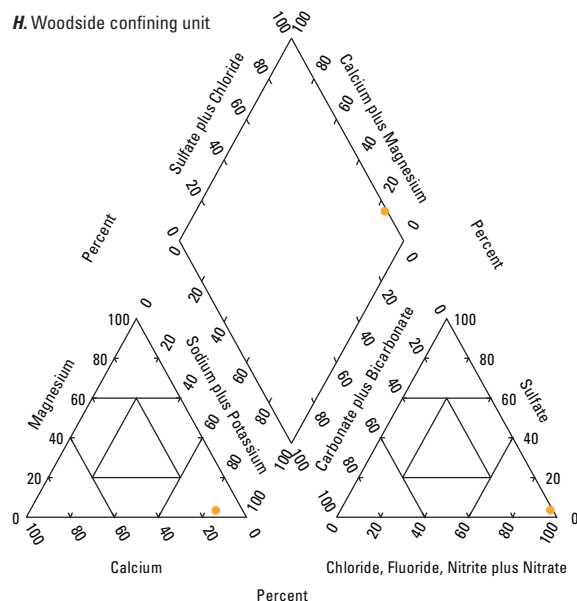
**F. Nugget aquifer**



**G. Thaynes aquifer**



**H. Woodside confining unit**



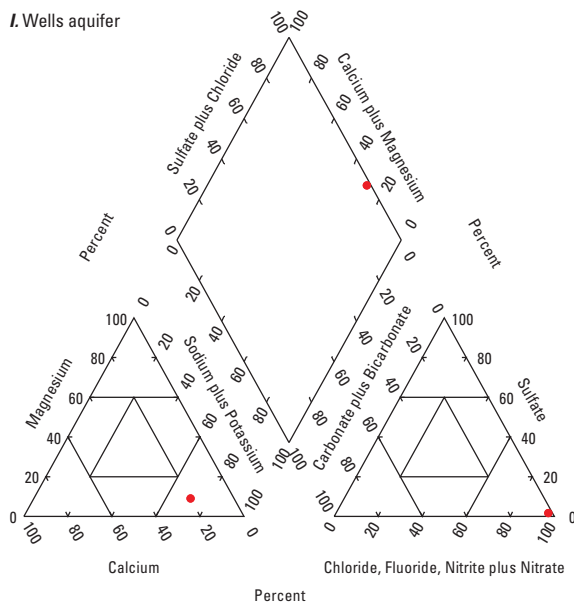
#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and  
U.S. Geological Survey salinity classification (Heath, 1983)

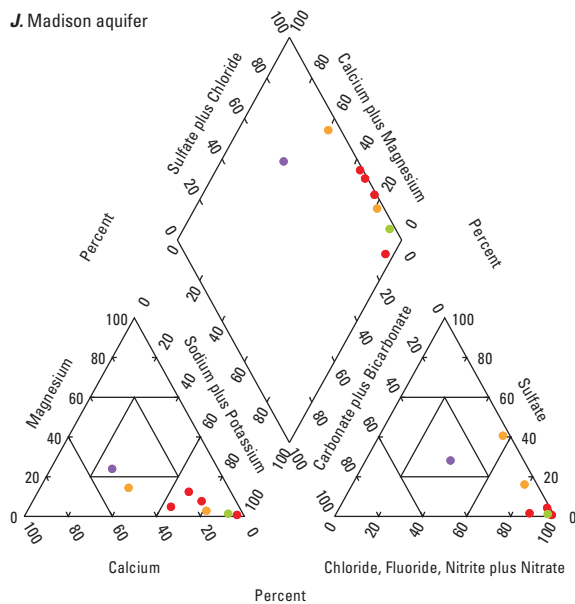
- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

**Appendix H.** Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for produced groundwater samples, Bear River Basin.—Continued

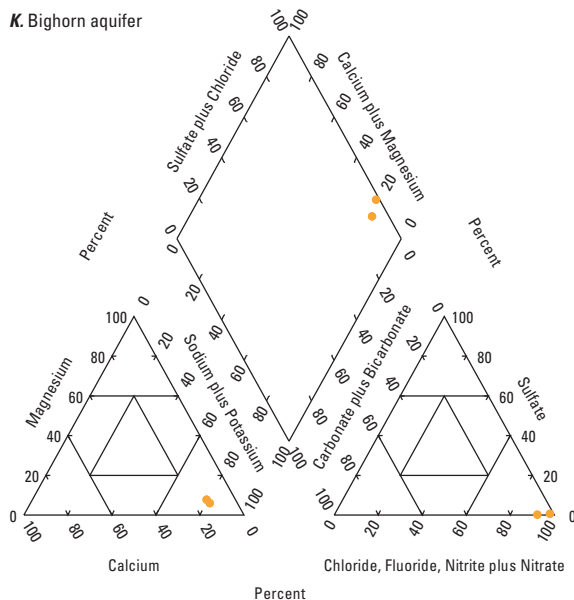
I. Wells aquifer



J. Madison aquifer



K. Bighorn aquifer



#### EXPLANATION

Total dissolved-solids concentration, in milligrams per liter, and  
U.S. Geological Survey salinity classification (Heath, 1983)

- Less than or equal to 999; fresh
- 1,000–2,999; slightly saline
- 3,000–9,999; moderately saline
- 10,000–34,999; very saline
- Greater than or equal to 35,000; briny

Appendix H. Trilinear diagrams showing major-ion composition and total dissolved-solids concentrations for produced groundwater samples, Bear River Basin.—Continued